0035170

ENGINEERING CHANGE NOTICE

1. ECN 196709

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. Date
Supplemental [] Direct Revision [x] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	J. A. Locklair, Environmental Restoration Safety Support, H4-67, 6-4409	3/1/94
	5. Project Title/No./Work Order No.: WHC-SD-EN-SAD-005, REV. 2, Soil Physical Separations Treatability Safety Assessment for 100 and 300 Areas	6. Bldg./Sys./Fac. No.	7. Impact Level: 2 ESQ
	8. Document Numbers Changed by this ECN (includes sheet no. and rev.): WHC-SD-EN-SAD-005, ~~REV. 0,~~ REV.1-A	9. Related ECN No(s).: 189924	10. Related PO No.: N/A

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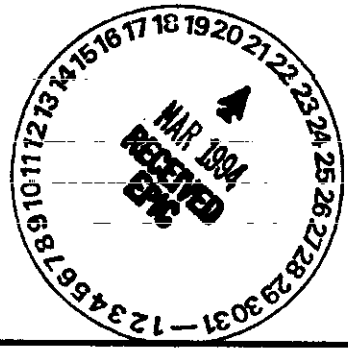
[] Yes (fill out Blk. 11b) [X] No (NA Blks. 11b, 11c, 11d)	N/A	N/A Cog. Engineer Signature & Date	N/A Cog. Engineer Signature & Date

12. Description of Change

Changes reflect the new system in WHC-SD-EN-TP-036, Rev. 0, *Soil Washing Physical Separations Test Procedure - 300 FF-1 Operable Unit*. Editorial changes were also made to improve readability.



13a. Justification (mark one)							
Criteria Change	[]	Design Improvement	[]	Environmental	[x]		
As-Found	[]	Facilitate Const.	[]	Const. Error/Omission	[]	Design Error/Omission	[]

13b. Justification Details

See Block 12.

14. Distribution (include name, MSIN, and no. of copies)

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15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
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[X] No	Savings	[ ] $	Savings	[ ] $	Delay	[ ]

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[ ]	Seismic/Stress Analysis	[ ]	Tank Calibration Manual	[ ]
Functional Design Criteria	[ ]	Stress/Design Report	[ ]	Health Physics Procedure	[ ]
Operating Specification	[ ]	Interface Control Drawing	[ ]	Spares Multiple Unit Listing	[ ]
Criticality Specification	[ ]	Calibration Procedure	[ ]	Test Procedures/Specification	[ ]
Conceptual Design Report	[ ]	Installation Procedure	[ ]	Component Index	[ ]
Equipment Spec.	[ ]	Maintenance Procedure	[ ]	ASME Coded Item	[ ]
Const. Spec.	[ ]	Engineering Procedure	[ ]	Human Factor Consideration	[ ]
Procurement Spec.	[ ]	Operating Instruction	[ ]	Computer Software	[ ]
Vendor Information	[ ]	Operating Procedure	[ ]	Electric Circuit Schedule	[ ]
OM Manual	[ ]	Operational Safety Requirement	[ ]	ICRS Procedure	[ ]
FSAR/SAR	[ ]	IEFD Drawing	[ ]	Process Control Manual/Plan	[ ]
Safety Equipment List	[ ]	Cell Arrangement Drawing	[ ]	Process Flow Chart	[ ]
Radiation Work Permit	[ ]	Essential Material Specification	[ ]	Purchase Requisition	[ ]
Environmental Impact Statement	[ ]	Fac. Proc. Samp. Schedule	[ ]		[ ]
Environmental Report	[ ]	Inspection Plan	[ ]		[ ]
Environmental Permit	[ ]	Inventory Adjustment Request	[ ]		[ ]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

20. Approvals

Signature	Date	Signature	Date
OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog Engineer G. C. Henckel III for W. L. Johnson	3/1/94	PE	
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QA T. L. Bennington T. L. Bennington	3/3/94	Safety	
Safety M. A. Tredway D. B. Tredway for	3-1-94	Design	
Security N/A		Environ.	
Environ. K. A. Gano K. A. Gano	3-1-94	Other	
Projects/Programs N/A		Radiation K. A. Smith K. A. Smith	3-1-94
Tank Waste Remediation System N/A		Ind. Safety L. C. Haslam L. C. Haslam	3/1/94
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Restoration & Remediation N/A		Signature or Letter No.	
Operations & Support Services N/A			
IRM N/A		ADDITIONAL	
Other ERSS N. R. Kerr for NRK	3/7/94		
RRSA J. J. Zimmer	3/7/94		

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INFORMATION RELEASE REQUEST

Reference: WHC-CM-3-4

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New or novel (patentable) subject matter? [X] No [ ] Yes
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Classification/Unclassified Controlled Nuclear Information	[ ]	[X]	
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SUPPORTING DOCUMENT

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6. Author
Name: J. A. Locklair
Signature
Organization/Charge Code 29550/PL3A2

3/11/94 D. Sola

7. Abstract

Potential hazards are addressed in this assessment and operational safety limits are provided to assure safe operation of soil physical separation treatment activities at the Hanford Site.

8. PURPOSE AND USE OF DOCUMENT - This document was prepared for use within the U.S. Department of Energy and its contractors. It is to be used only to perform, direct, or integrate work under U.S. Department of Energy contracts. This document is not approved for public release until reviewed.

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RECORD OF REVISION	(1) Document Number WHC-SD-EN-SAD-005	Page 1

(2) Title
Soil Physical Separations Treatability Safety Assessment for 100 and 300 Areas

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
1	(7) Rev. 0 released per EDT 129412 Rev. 1 released per ECN 189909 Rev. 1-A released per ECN 189924		
1	Changes expand the soil washing system to the 100 and 300 Areas.	G. C. Henckel III	W. L. Johnson
~~1-A~~	~~Replace table of contents and pages 8 and 9.~~ Additions explain if the evaporation option is exercised, effluent that has been processed by the water treatment system must meet specific purgewater criteria. Appendix E has been added to provide the purgewater collection criteria.	G. C. Henckel III (signature on file)	W. L. Johnson (signature on file)
2 RS	Replace the entire document. Changes reflect the new system in WHC-SD-EN-TP-036, Rev. 0. Editorial changes were also made to improve the readability of the document.	for G.C. Henckel III	W.L. Johnson
	ECN-196709		

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LIST OF FIGURES

LIST OF TABLES

SOIL PHYSICAL SEPARATIONS TREATABILITY SAFETY ASSESSMENT FOR 100 AND 300 AREAS

1.0 INTRODUCTION AND SUMMARY

A considerable amount of contaminated waste material has accumulated since the beginning of the Hanford Project in March 1943. This waste has been disposed of in over 1,400 waste disposal sites across the Hanford Site. The primary mission of the Hanford Site is to clean up the Site and eliminate potential risks to the public and workforce. Many applicable regulations direct and control this cleanup. The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990) is a legal agreement (also referred to as the Tri-Party agreement) reached among the U.S. Department of Energy, the Washington State Department of Ecology, and the U.S. Environmental Protection Agency. The primary purpose of the Tri-Party agreement is to provide a framework for cleanup of the Hanford Site. To meet the milestones in the Tri-Party agreement, different treatment methods are being considered to cleanup and reduce the volume of contaminated material from these waste sites.

The soil physical separation (soil washing) method was chosen to reduce the volume of contaminated soil fines that must be disposed of in permanent waste repositories. The soil washing activities will assess the effectiveness of soil physical separation equipment and techniques by using water and/or chemicals to separate contaminated material from the soil.

The purpose of this assessment is to (1) identify potential hazards associated with the soil washing activities, and (2) provide operational safety limits (OSL) and prudent actions to assure safe operation. Radiological and chemical hazards associated with removal of contaminants and pertinent risks are also addressed in this document.

The scope of the soil washing activities in this assessment are nonnuclear and low hazard. This assessment complies with DOE Order 5480.23 (DOE 1992b), DOE Order 5481.1B (DOE 1986), *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* (DOE 1992a), and WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*. This assessment also complies with 29 CFR 1910 for handling certain toxic heavy-metals. The rigor of review was appropriate for the nonnuclear low-hazard (radiological) classification.

1.1 ASSESSMENT SUMMARY

The radiological and toxicological dose consequences for this nonreactor-nonreactor activity are consistent with the criteria for low-hazard activities (WHC-CM-4-46; Schade 1991). Nuclear criticality is not an issue due to low enrichment of fissionable material involved.

Two technical inventories have been used as bases for radiological and toxicological calculations: sample soil analyses from the 300 Area West Process Trench taken in 1986 (Zimmerman and Kossik 1987) and in 1992. The most bounding radiological calculations are based on 100 Area base data from Dorian and Richards (1978). Resuspension factors are based on the worst conditions ever measured for the Hanford Site (3.5×10^{-6}/s). Radiological or

toxicological concentrations of hazardous material are not expected to result in harmful exposures to onsite workers (receptor groups are described in Section 3.1). These concentrations are well below risk acceptance criteria for the public.

This assessment applies to the soil washing activities to be performed at the (1) 100 Area liquid waste sites, (2) the 300 Area North Process Pond, and (3) the 300 Area West Process Trench. Excluded from this assessment are the 1301-N and 1325-N crib inventories.

Normal job-site worker safety requirements in the Hazardous Waste Operations Permit (HWOP), Job Safety Analysis (JSA), and Radiation Work Permit (RWP) provide adequate occupational safety, respiratory, and skin protection for the facility worker performing the soil washing activities. There is one prudent action (Section 4.2) that requires appropriate Westinghouse Hanford Company (WHC) safety approval of the HWOP, JSA, and RWP. Conformance to this action is verified during the readiness review process.

1.2 SUMMARY OF LIMITS AND PRUDENT ACTIONS

No unacceptable impacts are anticipated from the soil washing activities. However, two operational safety limits (OSL) have been provided to (1) minimize environmental impact and (2) reduce exposures to as low as reasonably achievable (ALARA). The OSLs will assure conformance with the requirements for a low-hazard activity. These OSLs apply to the control of fugitive dust and storage of effluent liquid and soil. Five prudent actions are also provided to reduce potential hazardous material exposures to ALARA. The OSLs and prudent actions are provided in Sections 4.1 and 4.2.

The following are summaries of the OSLs.

1. The soil shall be stabilized to prevent the emission of fugitive dust. The hazardous material inventory and anticipated air concentrations are expected to be low. The soil may become dry during nonwork hours and during transportation. Therefore, the soil shall be maintained damp or other stabilization methods shall be used to mitigate the emission of fugitive dust during soil washing activities and during transportation. If the soil is not stabilized properly, soil washing activities shall cease until the appropriate mitigative actions are implemented.

2. Contaminated soil and effluent liquid shall be stored and disposed of in a manner that prevents their release to the environment. Although the hazard material inventory is low, unmonitored storage over an extended time could allow temperature and atmospheric extremes to cause releases of hazardous material to the environment. Containment of the concentrated sludge material during disposal is required. Liquid and soil waste shall be stored and disposed in a manner that prevents their release to the environment (excluding evaporation). During containment, the waste shall be periodically assessed and if required, prompt action taken to stabilize and maintain safe storage.

The following are summaries of the prudent actions:

- Monitor equipment removed from the activity site to assure it is free of radiological contamination and (2) controlled in accordance with WHC requirements.

- Develop and implement a disposal plan to remove the contaminated material (fines) to a permanent waste repository on the Hanford Site.

- Use wind screens at the loading hopper (grizzly feeder) to minimize the potential of dust generated from the loading process.

- Minimize purgewater contaminants to the environment. Effluent processed by the soil washing method must meet purgewater criteria (or as directed by the State Department of Health) for discharge back to the soils before forced or solar evaporation.

- Conduct soil washing activities in accordance with the HWOP, JSA, RWP, and WHC-CM-7-7, *Environmental Investigations and Site Characterizations*.

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2.0 HANFORD SITE DESCRIPTION

This section provides a list of references of detailed studies on the regional background of the Hanford Site.

- Meteorology - Delaney et al. (1991) and PNL 1990
- Geology - Delaney et al. (1991)
- Hydrogeology - Liikala et al. (1988).

No one resides on the Hanford Site. Recreationists use the Columbia River throughout the year and have access to the west and south banks of the river. The nearest public road is State Highway 24, located 1.4 km (0.88 mi) from the closest 100 Area.

2.1 100 AREA DESCRIPTION AND HISTORY

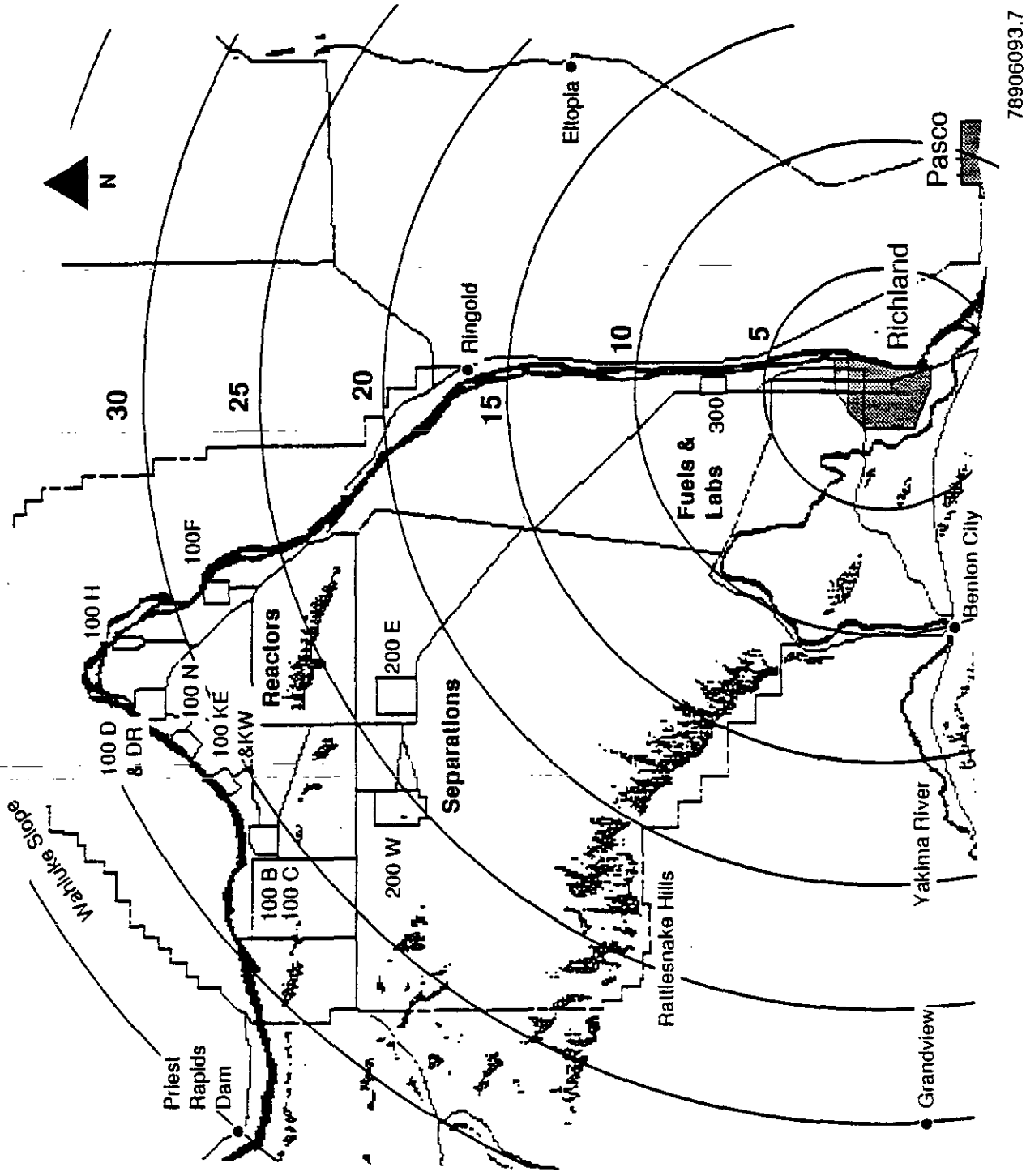
The 100 Areas are located in the northern portion of the Hanford Site, along the southern shoreline of the Columbia River. The 100 Areas are approximately 26 to 30 mi (41.8 to 48.3 km) north-northwest by northwest of the city of Richland (DOE 1987). The working population of the 100 Area complex varies on a daily basis; generally, however, the average is 150 to 200 people per day. The nearest resident to a 100 Area facility is located 8.1 km (5 mi) east of the 100-F Reactor Building and across the Columbia River.

Between 1943 and 1963, nine water-cooled, graphite-moderated plutonium production reactors were built along the Columbia River upstream from the now abandoned town of Hanford. These reactors (100-B, 100-C, 100-D, 100-DR, 100-F, 100-H, 100-KE, 100-KW and 100-N) have been retired from service and are under evaluation for decommissioning. Construction and operation dates, facility purpose, and year of shutdown for each reactor building is provided in Taylor (1991). Figure 2-1 provides the location of each of the nine reactor buildings along the Columbia River. Facilities were constructed to dispose of liquid wastes generated from fuel failures, decontamination facilities, and liquid and sludge from the irradiated fuel storage basins. These facilities (cribs and trenches) are described and characterized, including radiological inventories, in Dorian and Richards (1978).

2.7 300 AREA DESCRIPTION AND HISTORY

The 300 Area is located in the southeast portion of the Hanford Site, approximately 1.6 km (1 mi) north of the city of Richland in Benton County (Figure 2-2). The working population of the 300 Area varies on a daily basis; however, the estimated average is 200 to 300 people per day. Based on soil washing activity site locations, the 300 Area provides the closest offsite receptor group for risk analysis. The west bank of the Columbia River is located about 275 m (900 ft) and 330 m (1,080 ft) from the activity sites at the 300 Area North Process Pond and West Process Trench, respectively. Hazardous material concentrations at the Columbia River bank and offsite are expected to be insignificant and not pose a health hazard.

Figure 2-1. Location of Reactor Buildings.



The 300 Areas were involved in the processing of uranium into fuel assemblies for use in the 100 Area reactors. The process involved heating and extruding the uranium into specific sizes and encapsulating the uranium fuel within an outer shell of metal alloy. The fuel production liquid by-products were discharged into the ponds and trenches within the 300-FF-1 Operable Unit (Figure 2-3).

Liquids and particulates in solutions disposed of in the 300 Area process ponds and trenches over the years included the following:

- All metallic and chemical components of the fuel fabrication process
- All separations-process chemicals and solutions (particularly uranyl nitrate hexahydrate) used in the following processes:
  -Bismuth phosphate tests conducted in the 3706 Building and 321 Building
  -Reduction oxidation
  -Metal recovery
  -Plutonium-uranium reduction extraction
  -RECUPLEX.

Chemicals used in bioassay and environmental sample analyses also contributed a much smaller portion of the 300 Area process wastes (Gerber 1992).

2.8 PURPOSE

The purpose of the soil washing activities is to evaluate methods and equipment used to reduce the volume of contaminated soil sent to waste repositories on the Hanford Site. These activities will demonstrate the applicability and effectiveness of commercially available soil physical separations equipment that use water as the washing medium. Additives may also be used with the water to enhance the effectiveness of the cleaning process. The information and experience gained may be applied to other waste sites in support of the proposed macroremediation program.

2.9 SCOPE

The scope is limited to soil washing activities and equipment using water and additives for the extraction of hazardous substances and onsite storage of the contaminated material. The 300 Area contaminated material will be soil from the North Process Pond and the West Process Trench. The location of the activities will be in and adjacent to the southwest corner of the North Process Pond and east of the West Process Trench. The 100 Area contaminated material will be soil from the cribs and trenches analyzed in Dorian and Richards (1978).

Figure 2-2. Hanford Site.

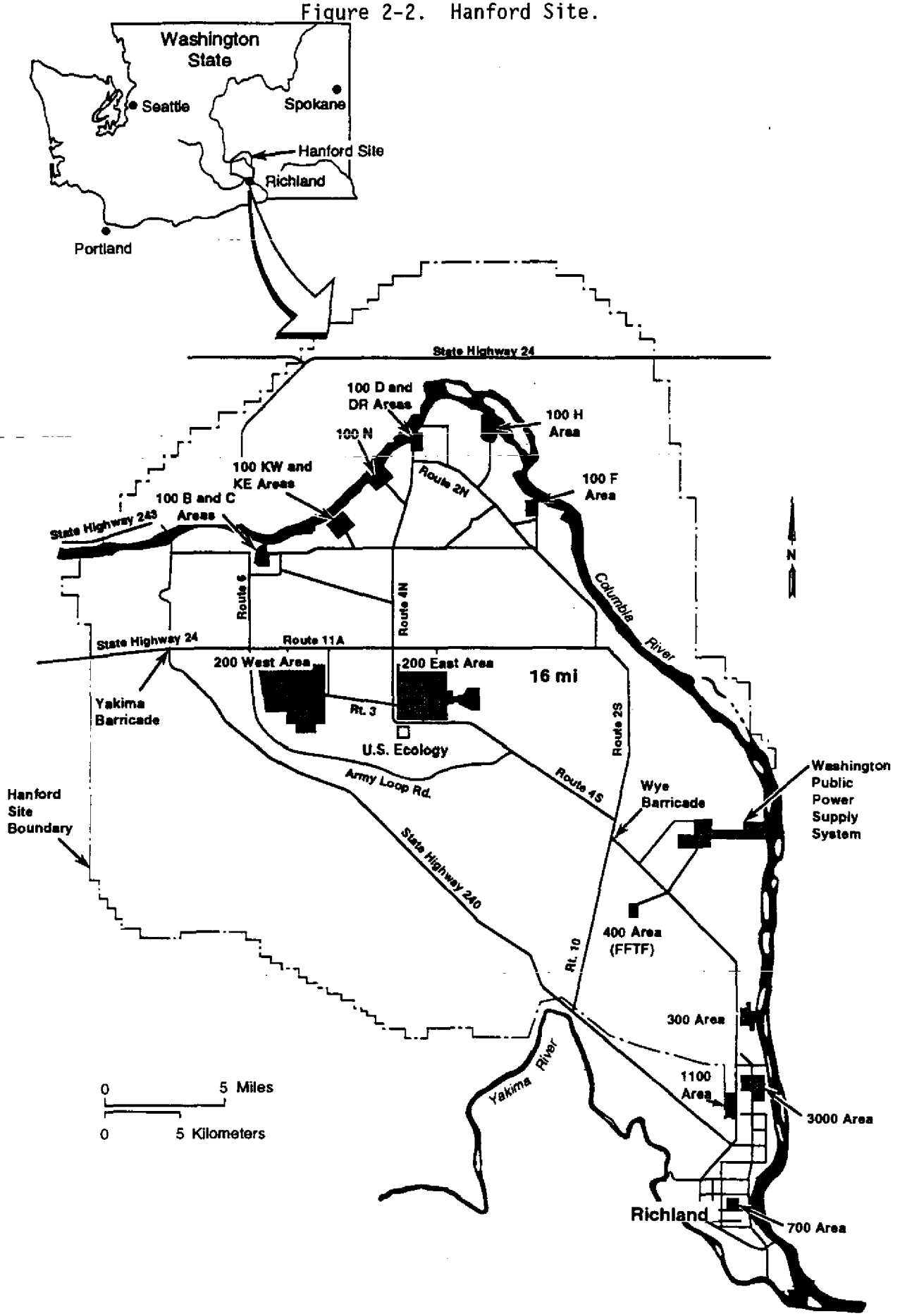
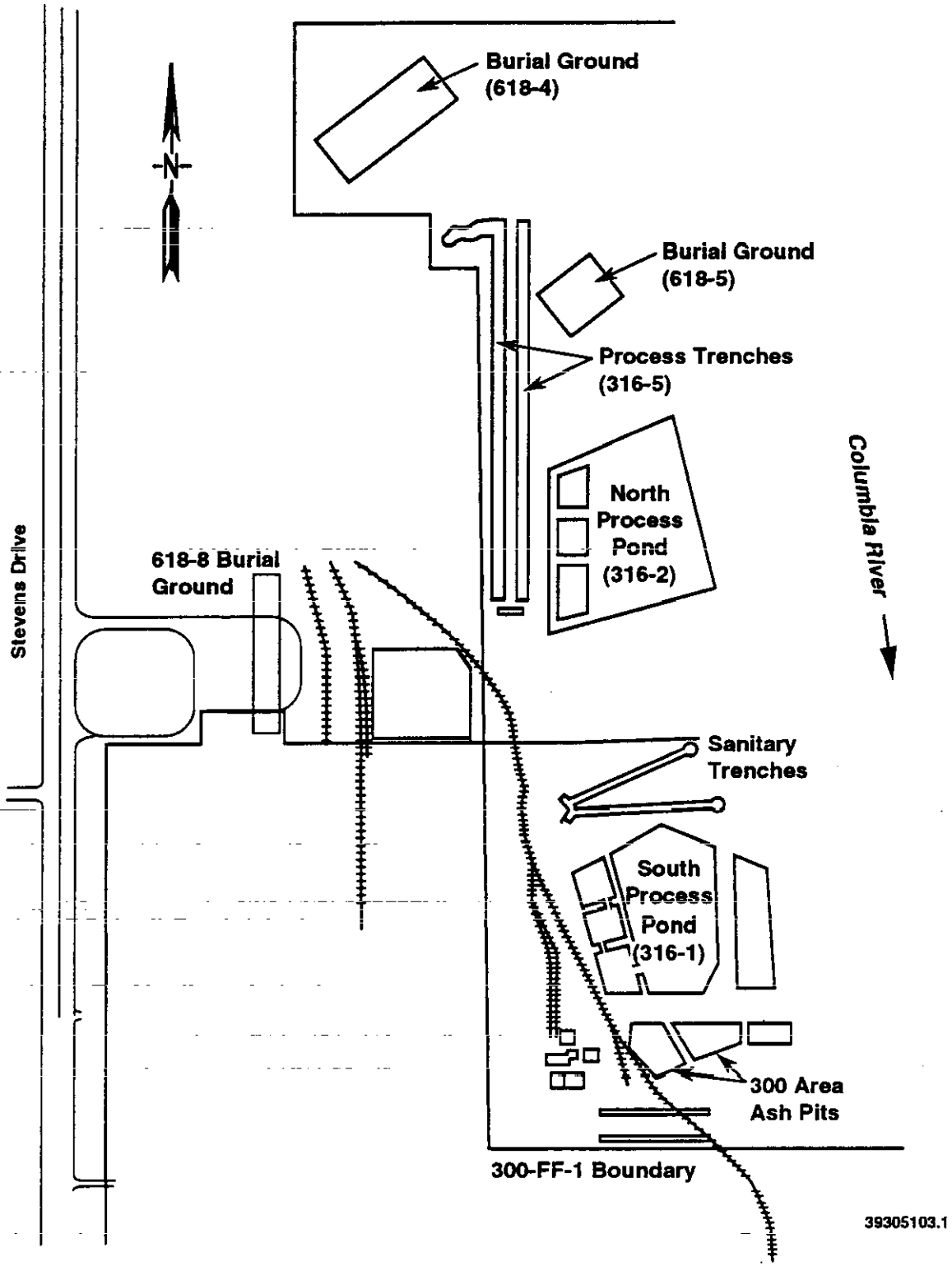


Figure 2-3. Layout of the 300-FF-1 Operable Unit.



The clean gravel, rock, and sand will be returned to the excavation site after treatment. The hazardous material particulates will be collected and stored in an onsite waste repository for an undetermined time period. Storage of hazardous material will comply with requirements specified by regulatory agencies until a disposal plan is developed and implemented.

2.10 PROCESS DESCRIPTION

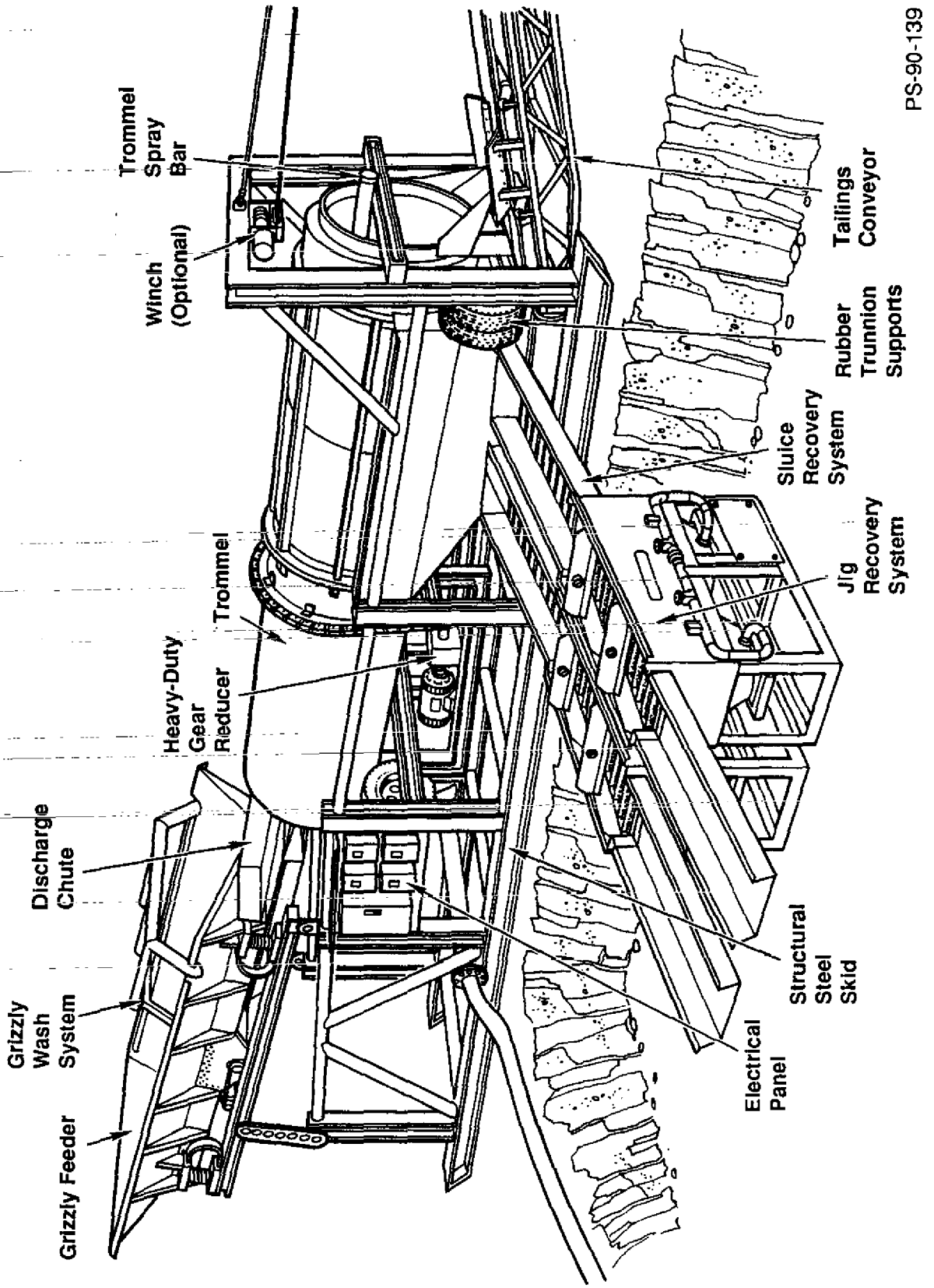
Soil physical separation treatment processes have been used for many years in the mineral processing industry for removing materials by washing and concentrating a desired particle size or mineral. The soil washing activities in this assessment have the potential to reduce the volume of contaminated material by 80% to 90%. Separation equipment consists of a wet hopper (grizzly feeder) that will separate rocks and other large debris and remove contaminants by washing. A sketch of a typical placer system is shown in Figure 2-4. A detailed description of the treatment process and equipment is provided in Field and Henckel (1991).

Soil and rock material will be stabilized to prevent the emission of fugitive dust. The material will be removed from the North Process Pond and West Process Trench (located about 4.6 m [15 ft] belowgrade) using front-end loaders or similar equipment. The material will then be transported to the nearby separation equipment site, loaded on a conveyer belt system, and washed with water and chemical extractants to partition radioactive and hazardous chemical constituents. The chemical extractants will be nonhazardous and environmentally acceptable. The gravel and coarse sand will be separated from fine sand, silt, and heavy metals using classification equipment to segregate fine particles. Following dewatering, the clean gravel, rock, and sand will be returned to the excavation site. Dewatered material is estimated to retain a moisture content of approximately 20%; this retained moisture content will eliminate any dust generation during transport back to the storage site in the North Process Pond or West Process Trench. Most of the dust source will be in the final product of the process.

Most hazardous material is expected to be particles or attached to particles smaller than 106 μm. Particles are expected to be removed in the water-wash stream and settle out in the containment units. There are three primary options for disposing of contaminated particles:

1. Place contaminated material in containment units (i.e., drums or boxes) and immediately transport to a waste repository in the 200 Areas, or store at the activity site temporarily and then ship to a waste repository.

Figure 2-4. Typical Placer System.



2. Return contaminated material to the source locations in the 300 Area North Process Pond or West Process Trench. Permanently stabilize material or cover with the clean soil material.

3. Store the contaminated material for an undetermined length of time in the containment units to allow sampling and analysis. Develop and implement a permanent disposal plan for the contaminated solids and effluent water following sampling and analysis.

Particulates will be removed from the effluent water and stored in a containment unit or returned to the source location. Effluent water processed in soil washing activities will be recycled and stored in containment units for sampling and analysis. The water will be evaporated or disposed of in accordance with applicable WHC and DOE requirements. If the evaporation method is used, effluent water must meet purgewater criteria (or as directed by the State Department of Health) for discharge back to soils before forced or solar evaporation. Appendix E provides the purgewater collection criteria from Table 8.3 in WHC-CM-7-5, *Environmental Compliance*.

An OSL (Section 4.0) is provided to assure the integrity of the containment unit and confinement of the stored contaminated solids and liquid. Environmental Engineering management has taken action to identify disposal requirements before process startup reviews.

Appendix D provides a description of the closed-loop water treatment system. Additional filtration may be added at a later date to remove contaminants to below regulatory concern (i.e., ion exchange). However, if filtration is added to the system, further safety analysis is required.

The 300 Area soil physical treatment equipment will be located in or adjacent to the southwest corner of the North Process Pond and adjacent to the east side of the West Process Trench. The 100 Area soil treatment equipment will be located adjacent to the crib or trench. The equipment locations are near the contaminated soil inventories that will be used in the soil washing activities. Short travel distance between the source material location and the soil separation equipment will minimize the potential for fugitive dust generation.

The OSLs in Section 4.1 require (1) soil material be stabilized to reduce fugitive dust emissions from the soil washing activities; and (2) appropriate action be taken to minimize the potential for environmental release of contaminated soil and effluent liquid during onsite storage.

The initial soil washing activity location at the 300 Area North Process Pond is about 275 m (900 ft) west of the Columbia River. The distance from the West Process Trench is about 330 m (1,080 ft) to the river. The initial soil washing activity location for the 100 Area is approximately 61 m (200 ft) southwest of the 105-F Reactor Building at the 116-F-4 Pluto Crib.

The soil washing activities are expected to be performed during the second and third quarter of 1994. The actual work time that equipment will be operating at the North Process Pond will not exceed 15 work days. Two demonstration runs are planned at the North Process Pond; each run will process 150 to 380 tons of soil. The processing rates for the runs will not exceed 10 and 20 tons/h, respectively. The equipment operating period is expected to extend over several weeks at the 300 Area West Process Trench. If

the siting requirements for the 300 Area activities change, a re-evaluation of potential encroachment issues shall be performed. The 100 Area sites (independently) are not expected to process the volume described for the 300 Area activities; however, if the process proves viable, the total volume of the 100 Areas will exceed the volumes estimated for the 300 Area activities.

2.11 HAZARDS INVENTORY

Two technical inventories were used as bases for radiological and toxicological calculations: sample soil analyses data for the 300 Area West Process Trenches taken in 1986 (Zimmerman and Kossik 1987) and in 1992. The most bounding radiological calculations are based on 100 Area base data extracted from Dorian and Richards (1978).

The basis for the toxic material and inhaled dose inventory in this assessment is soil removed during the expedited response action for the 300 Area process trenches in 1991. The inventory for the 300 Area West Process Trench is provided in Zimmerman and Kossik (1987). The contaminant inventory in the soil was derived by taking the highest average concentration value of samples from any 33 m (100 ft) segment of the process trench. The metal contaminant inventory (Table 2-1) is considered to be conservative for assessment purposes. During removal from the West Process Trench, the clean and contaminated soil material will mix from the action of the earth-removal equipment that will lower the concentration of the contaminant source materials. Clean soil cover will dilute the concentration further.

The hazardous material concentrations and inventory for the 300 Area process trenches are greater than concentrations in the 300 Area North Process Pond. Therefore, the 300 Area West Process Trench inventory is the basis for calculations performed for the North Process Pond analysis. This conservative hazardous material inventory is the basis for the facility hazard classification.

The radiological inventory is based on a hypothetical basis for the 116-C-2-2 Pluto Crib Sand Filter. The inventory of the sand filter is assumed to be spread over the volume of the 116-C-2-2 Crib and considered to be the bounding source term for this assessment. The exception to inventory consideration in the 100 Areas is the 116-N-1 site (1325-N and 1301-N crib and trench). This conservative bounding inventory for the two locations (100 Area and 300 Area) in this assessment was chosen because it represents the largest potential hazardous material inventory based on the results of characterization sampling in the North Process Pond and West Process Trench (Dennison et al. 1989; Dorian and Richards 1978).

The treatment process will separate the hazardous materials inventory from the contaminated soil material. The hazardous inventory is expected to be (or be attached to) fine particles less than 106 μm in diameter. Typical concentrations for the separated soil fines samples are provided in Tables 2-2, 2-3, and 2-4; these samples were enriched in fines by screening before analysis (Zimmerman and Kossik 1987).

Table 2-1. Estimated Total Amount of Metal Contaminants in the 300 Area Process Trench Sediment.

Constituent	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Uranium
Shallow sediments (kg)	3	341	2,261	108	12.8	578	54	720

Source: Zimmerman and Kossik (1987).

Table 2-2. Potentially Contaminated Soil Column for 116-C-2-2 Pluto Crib Sand Filter.

Radionuclide	Average Pci/g	Curies
^{238}Pu	1.9 E+01	1.2 E-01
$^{239/240}Pu$	1.9 E+01	1.2 E-01
^{90}Sr	3.6 E+02	2.2
^{3}H	7.3 E+01	4.5 E-01
^{152}Eu	1.3 E+03	7.9
^{60}Co	3.7 E+04	230
^{154}Eu	1.0 E+02	6.1 E-01
^{134}Cs	6.5 E+01	3.9 E-01
^{137}Cs	1.7 E+03	10
^{155}Eu	1.1 E+03	6.7
		Total curies = 260

Source: Dorian and Richards (1978).

Table 2-3. Toxic Concentrations Caused by Wind Dispersion.

Substance	Soil concentration[a] (ug/g)	Soil background (ug/g)	Maximum ground level concentration in air at 100 m (330 ft) (mg/m^3)	Exposure limits	
				TWA	IDLH
				(in mg/m^3)	
Silver	362	<1	1.6 E-04	0.01	n/e
Chromium^{+6} [b]	604	6-10	2.7 E-04	0.05	30
Copper	95,300	8-22	4.2 E-02	1.0	n/e
Nickel[b]	1,750	5-9	7.7 E-04	0.1	n/e
Uranium	9,370	0.6-8	4.1 E-02	0.2	20

n/e = none established.
[a] Credible calculated values.
[b] Carcinogen.

Table 2-4. Hazard Threshold Values.

Hazard category	Facility worker	Onsite	Offsite
General use	--	--	--
Radiological	<Exempt quantity	--	--
Chemical	none listed	<0.1 IDLH	<0.01 IDLH
Low hazard	--	--	--
Radiological	≥Exempt quantity <25 rem	≥0.1 rem <5.0 rem	≥0.01 rem <0.5 rem
Chemical	none listed	≥0.1 IDLH	≥0.01 IDLH

Source: Schade (1990).

The only significant radiological element found in the sediment analysis for the 300 Area was uranium. Trace concentrations of ^{60}Co, ^{137}Cs, and ^{65}Zn were found in the West Process Trench weir box sediments. Several nonradiological hazardous materials were also detected, along with significant concentrations of chromium, copper, nickel, and uranium (Zimmerman and Kossik 1987).

The 100 Area liquid disposal sites have received a significant amount of aqueous waste from reactor operations in the past; isotopes of interest include ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{60}Co, ^{137}Cs, ^{90}Sr, and ^{63}Ni. Based on historical data for the 100 Areas, nonradioactive wastes introduced into the soils include sodium dichromate, sodium oxalate, sodium sulfamate, sulfuric acid, bauxite, lubricating oil, gasoline, and oil contaminated with polychlorinated biphenyls (Taylor 1991). Because the contaminants have been in the soil for several years, the assumption is that soluble materials have leached from the soil material to be processed. The remaining contaminants are solids or are firmly attached to soil particles.

There are several additional organic and inorganic nonradioactive materials above background levels. These materials are in trace amounts or very low concentrations that are very small fractions of the time weighted average[1] (TWA), the immediately dangerous to life and health[2] (IDLH), or the lower explosive limit values. These materials are not expected to result in detectable airborne concentrations, and because of their small amount, are not included in the inventory in this assessment.

[1]The time weighted average concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect (ACGIH 1990).

[2]The maximum concentration of a substance in air from which an unprotected worker could escape within 30 minutes without experiencing escape-impairing or irreversible health effects (NIOSH 1990). The IDLH is considered a maximum concentration above which only a highly reliable breathing apparatus providing maximum worker protection is permitted.

The following are the potential hazards to facility workers at the soil washing activity site:

- Radiation exposure
- Inhalation of contaminated particulates
- Noise
- Moving equipment
- Electrical shock
- Electrical generator fire
- Radiological issues.

This assessment focuses on the potential consequences relating to releases of contaminated particulates.

2.12 RELEASE SCENARIOS INVOLVING NATURAL PHENOMENA

Natural phenomena events such as tornadoes, floods, seismic events, and lightning do not significantly increase the risk associated with soil washing activities. Expected frequencies for these events at the Hanford Site are provided in Lehrschall (1992).

High wind speeds up to 169 km/h (112 mi/h) are a credible occurrence at the Hanford Site (>1.0 x 10^{-6}/yr) (Kennedy et al. 1990). Along with resuspension of dust, missiles generated by high winds could penetrate the interim storage drums and cause surface spills or airborne releases. However, soil washing activities are not allowed during wind speeds greater than 24 km/h (15 mi/h). The consequences associated with high winds/missiles would be bounded by the maximum release event.

Normal wind speeds of 4.8 km/h (3.0 mi/h) would not a represent significant risk to the soil washing activities. An analysis (Lehrschall 1992) for the BX-102 site involving three cable-drilling drive barrels exposed to a 24 km/h (15 mi/h) wind for 1 hour and 8 hours found the consequences to be insignificant to the uninvolved onsite worker and the public. Conservative release fractions and radionuclide concentrations were used. Activities would be expected to encounter much lower concentrations of radionuclides in the nCi to pCi per gram range compared to the uCi/g concentrations at the BX-102 site.

Contaminated particulates suspended in the air by wind erosion is a function of the physical forces acting upon the particle. Dust particles typically are less than 1 um to 50 um in size; particles larger than 10 um are not respirable. Particles above 50 um are subject to saltation and are not suspended for extended periods of time. Movement of particulates depends on the size of the particle, speed of the airstream, gravitational forces, and air viscosity (GPO 1968). Movement of particulates also depends on soil properties, such as adhesiveness and cohesiveness. Moisture acts as an adhesive and holds particles together. With sufficient moisture, no wind erosion will occur.

Surface roughness and the presence of vegetation or irregularities (e.g., rocks) also suppress wind erosion. Air turbulence is also important as it is more effective in resuspending dust than steady velocity air.

Below the threshold velocity of approximately 20 km/h (13 mi/h), no wind erosion release occurs. This analysis conservatively uses the highest resuspension rates measured at the Hanford Site (3.5×10^{-6}/s [Sehmel 1980]) as the basis for source term estimation. Higher resuspension rates are possible at the high wind velocities that exist during dust storms, but the dilution effect also increases with wind velocity as X/Q gets smaller with increasing wind speed. Thus, the effect of very high wind speeds on downwind contaminant concentrations is complicated. Ambient air dust loadings as high as 2,724 ug/m^3 have been reported for dust storms in the Tri-City area. The worst-case value used for these soil washing activities is 10,000 ug/m^3.

Particulates retained in the lungs are expected to be less than 0.5 um in size; this particle size will account for almost 50 percent of all particulates retained. Particles larger than 0.5 um will be from 0.5 to 50 um. Normally, particles larger than 50 um are prevented from reaching the lungs by nasal hair and flow paths. The following are examples of typical particle sizes (NIOSH 1973):

- Clay - 0.1-2.0 um
- Silt - 2.0 to 20.0 um
- Fine sand - 20.0 to 120.0 um
- Coarse sand - 120.0 um to .2 mm

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3.0 HAZARD ASSESSMENT

3.1 INTRODUCTION

The soil washing activities will be performed (1) in and near the southwest corner of the North Process Pond; (2) the north end of the West Process Trench in the 300 Area; and (3) in the 100 Area liquid disposal sites. The process will employ soil separation equipment using water and additives to enhance the cleaning effectiveness. Additives will be nonhazardous and acceptable to the environment. The following are the receptor groups of concern:

- Workers involved in the soil washing activities (referred to as facility workers)
- Onsite workers (located at least 100 m [330 ft] or beyond from the soil washing activities)
- Public (located offsite on the west bank of the Columbia River).

Different energy sources that could cause a hazard inventory to become a source term were analyzed. Mechanical energy of process equipment, equipment fuel fires, range fires, and wind are considered the most probable initiators of a source term. For assessment purposes, wind combined with mechanical action are the initiators used for the generation of a source term, as wind is common to the soil washing activities while the other initiators considered were not. Further, a combination of wind, dry soil material, and mechanical action would result in the receptor groups receiving the largest credible exposure to hazardous materials.

Other naturally occurring energy sources also were analyzed in this assessment. Because the worst case has been assumed, natural phenomena events would not adversely affect the conclusions in this assessment. The effects of these events on the inventory would be minimal because the dispersion from other inventories resulting from these forces would be greater than the inventory of the activity assessed. Lightning would not cause a source term greater than that assessed if lightning were to strike the rubber-tired transport vehicle.

Nuclear criticality is considered incredible because of the small amount and type of uranium in the soil material in the North Process Pond and West Process Trench (Appendix A). The average uranium enrichment in the trenches was determined to be less than 1.0 wt% ^{235}U and all sampling indicates a homogeneous distribution of uranium in the soil matrix (Appendix A; Zimmerman and Kossik 1987). The amount of all forms of uranium in the process pond was also below the nuclear criticality minimum level (Dennison et al. 1989). The average plutonium concentration per gram of soil in the 116-C-2-2 Crib is approximately 3.9×10^{-11} Ci or 39.0 pCi/g, which is below the matrix distribution limit specified in WHC-CM-1-6, *Radiological Control Manual* for gross alpha. The plutonium concentration also is below the 1.9×10^{2} pCi/g as specified in WHC-CM-7-5 for unrestricted access. This concentration is approximately 39.0 uCi/907.18 kg (1 ton) of soil. The major dose contributor for the 116-C-2-2 Crib would be ^{60}Co. An estimate on the total curie content for the 116-C-2-2 Crib is in Dorian and Richards (1978). If 230 Ci of ^{60}Co were decayed from 1978 to 1993 and ^{60}Co has a half life of 5.271 years, then

28.75 Ci is assumed to remain in the crib. This estimate would produce 4.71 x 10^3 pCi/g of Co^{60} in the soil column. Assuming the total mass for the crib was approximately 7.28 x 10^4 tons of soil, an estimate of 395 uCi/907.18 kg (1 ton) would be appropriate.

3.2 ASSESSMENT

There are three parts to this assessment:

- Assessment and comparison of the overall worst case inventories to the corresponding threshold for nuclear category 3 (DOE 1992a).
- Assessment of the toxicological and radiological risk from inhalation of contaminated fine material resuspended by wind from the back of a dump truck.
- Assessment of radiological risk from direct exposure based on a source term contained in a dump truck full of contaminated soil.

Two inventories were reviewed to evaluate worst case waste sites in the 300-FF-1 Operable Unit and the aggregate 100 B/C Area. The radiological inventories for the 300 Area West Process Trench (Kerr 1992) and the 116-C-2-2 Crib (Dorian and Richards 1978) were decayed to 1993. The comparison of the worst case inventories and the corresponding threshold for nuclear category 3 (DOE 1992a) is summarized in Table 3-1. It is shown that no isotope exceeds the category 3 threshold. Accordingly, the soil washing activities are classified as nonnuclear activities (as defined in DOE 1992a and DOE 1992b).

Table 3-1. Maximum Radionuclide Inventories for the 100 and 300 Areas and the Corresponding Limits in DOE 1992a (decayed to 1993).

Area	Location	Isotope	Inventory (Ci)	Category 3 (Ci)
300	316-5 Process Trench	^{60}Co	1.0	2.8 E+02
		^{238}U	1.4	4.2
100	116-C-2-2 Crib	^{3}H	1.9 E-01	1.0 E+03
		^{60}Co	3.21 E+01	2.8 E+02
		^{90}Sr	1.5	1.6 E+01
		^{134}Cs	2.5 E-03	4.2 E+01
		^{137}Cs	7.1	6.0 E+01
		^{152}Eu	3.3	2.0 E+02
		^{154}Eu	3.1	2.0 E+02
		^{155}Eu	8.2 E-01	9.4 E+02
		^{238}Pu	1.1 E-01	3.6
		^{239}Pu ^{240}Pu	1.2 E-01	9.0 E+02

*DOE-STD-1027-92 standards (DOE 1992a).

The consequences from a bounding case accident scenario was determined. For assessment purposes, the source term is created during (1) transport of the fine materials from the containment unit to a disposal destination or (2) during transport to the containment units assuming the fine material migrates to the top of the load. The contaminants are expected to be fine particulates or attached to fine particles. The gravel and coarse sand are expected to contain minimal residual hazardous material. Transportation equipment involved is a 9.1 m^3 (10 yd^3) capacity dump truck. It is assumed the truck bed area is 9 m^2 (97 ft^2), the soil material is dry, and the truck is located at ground level.

Removal of the contaminated fine material from the containment unit will be done while the material is in a stable condition. The contaminated fine material will either be placed in containment units for shipment to a Hanford Site waste site repository or returned to the source locations in the 300 Area North Process Pond or West Process Trench where the material will be stabilized. The output from the soil washing activities will be less than 10% to 20% fine sand and the remainder will be gravel and coarse sand. If the fines were to become dry without stabilization protection, they would represent a potential source term.

For this scenario, the basis for the toxic material inventory used is soil material removed from the 300 Area West Process Trench. Analysis of that inventory included screening out coarse material (see section 2.11).

The following assumptions have been made for this scenario. The The contaminated soil material in the truck is dry and the top of the sides of the truck bed are 2.4 m (8 ft) from ground level and filled to capacity. The wind is from the east at 21 km/h (13 mi/h). If the truck is entering the pit, it will remain at ground level while moving to the east a distance of 402 m (0.25 mile) at 24 km/h (15 mi/h) before descending to the bottom of the trench 4.6 m (15 ft) belowground level. The trip duration is about 60 seconds.

A source term is generated by wind blowing across the surface of the dry, contaminated soil in the truck bed. Fugitive dusts containing radioactive nuclides are then carried downwind, creating a maximum concentration at 100 m (330 ft) of 1.92×10^{-5} mg/m^3 of ^{60}Co by volume at ground level. A conservative resuspension rate of 3.5×10^{-6}/s, the highest rate postulated for the Hanford Site (Sehmel 1980), was used. The downwind concentration was estimated using Emergency Prediction Information[3] software (Appendix B).

The resulting toxicological concentrations shown in Table 2-3 are well below regulatory limits for the receptor groups.

The radiological dose from inhalation of resuspended fine material uses the same source term and scenario described in Section 3.2. The nuclides of concern for the 100 Area and the 116-C-2-2 Crib are ^{90}Sr and ^{60}Co, respectively. Conservative calculations using ^{60}Co (shown in Appendix B, Wind Dispersion Model) show that the predicted inhaled dose is well below levels that require worker respiratory protection. Therefore, the risk to the onsite worker would be less significant.

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[3]Emergency Prediction Information is a registered trademark of Homann Associates, Inc., Fremont, California.

The second scenario bounds the radiological risk. Calculations estimate the dose rates from a dump truck containing a full load of contaminated soil. The hypothetical source term is based on the 116-C-2-2 Crib that is mixed into the entire volume of the Pluto crib (see Section 2.10). The major dose contributor using this model is ^{60}Co. Dose rates were estimated using Micro-Shield[4] software.

Resulting dose rates are provided in Table 3-2 for various distances from the truck. The first row in the table shows the results if the entire inventory of the crib is assumed to be mixed within the dump truck bed; this is a highly conservative assumption. A more reasonable calculated dose is shown in the second row. In this calculation, the truck holds only that fraction of the inventory represented by the ratio of the volume of the truck to the volume of the crib.

Table 3-2. Exposure Rates from Bounding Case Inventory

Distance	Contact at truck sidewall	.3 m (1 ft)	.6 m (2 ft)	.9 m (3 ft)	1.2 m (4 ft)	1.5 m (5 ft)	1.8 m (6 ft)
Dose rates (mr/h)	2,811 8.97	1,997 6.38	1,299 4.14	904 2.88	661 2.1	520 1.66	392 1.25

Soil washing activities will presumably concentrate the contaminants of concern as soil material is processed. If estimates are conservatively increased an order of magnitude, for a container that is the same size as the carrier, a contact dose rate will increase to approximately 90 mr/h. Smaller containers will have proportionally lower dose rates. This dose rate is still within the criteria for a low-hazard activity. The dose rates in Table 3-2 can be compared to the criteria in Table 2-4.

Potential concentrations of hazardous materials are well below regulatory limits as is the potential radiological insult to the receptor groups. The receptor groups are described in Section 3.1.

The 300 Area provides the closest offsite receptor group for risk analysis based on soil washing activity locations. Although the 300 Area does not contain the inventories normally associated with 100 Area liquid disposal sites, those radionuclide inventories were included as a conservative estimate for risk analysis. The west bank of the Columbia River is located about 275 m (900 ft) and 330 m (1,080 ft) from the activity locations at the North Process Pond and the West Process Trench, respectively. Concentrations decrease the further the receptor group is from the source term. Therefore, concentrations at the Columbia River bank and offsite are expected to be insignificant and not pose a health hazard.

[4]Micro-Shield is a registered trademark of Grove Engineering Inc., Rockville, Maryland.

3.3 SUMMARY AND CONCLUSIONS

The radiological and toxicological dose consequences for this nonreactor-nonnuclear activity are consistent with the criteria for low-hazard activities (WHC-CM-4-46; Schade 1991). Two technical inventories were used as bases for radiological and toxicological calculations: sample soil analyses data for the 300 Area West Process Trench taken in 1986 (Zimmerman and Kossik 1987) and in 1992. The most bounding radiological calculations are based on the 100 Area base data in Dorian and Richards (1978). Resuspension factors are based on the worst conditions ever measured at the Hanford Site (3.5×10^{-6}/s).

Radiological or toxicological concentrations of hazardous material are not expected to result in harmful exposures to onsite workers (located a distance of 100 m [330 ft]). Concentrations are expected to be well below risk acceptance criteria for offsite individuals. Nuclear criticality is not an issue because of the small amount of fissionable material involved.

This assessment applies to soil washing activities performed at (1) the 100 Area liquid waste sites, (2) the 300 Area North Process Pond, and (3) the 300 Area West Process Trench. Excluded are the 1301-N and 1325-N Crib inventories.

Job-site worker safety requirements in the HWOP, JSA, and RWP will provide adequate protection for the facility worker and the uninvolved onsite worker. Committed mitigation efforts will ensure ambient air for the facility worker so respiratory protection is not required. Normal health physics requirements require air sampling to verify the existence or absence of airborne contaminants in the work environment. Radiological and industrial hygiene practices will provide protection to the three receptor groups (defined in Section 3.1) during offnormal circumstances.

There is no credible scenario that could result in a fire. The lack of combustible material near the soil washing activities precludes any further analysis. An electrical fire is possible; however, the fire would be enveloped by the postulated dispersion of contaminated soils by wind.

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4.0 OPERATIONAL SAFETY LIMITS AND PRUDENT ACTIONS

An OSL is an auditable limit for the safe operation of a nonreactor nuclear facility or activity. The U.S. Department of Energy, Richland Operations Office has required that at least one acceptable limit be provided to assure the facility or activity is operated safely and within the bounds of the safety assessment. Two OSLs have been established to assure the validity of this assessment and to minimize exposure and environmental impact to ALARA. These OSLs require (1) that the potential for fugitive dust be minimized and (2) that contaminated soil and effluent liquid be stored onsite and disposed of in accordance with regulatory requirements.

4.1 OPERATIONAL SAFETY LIMITS

Operational Safety Limit - 1

This OSL applies to minimizing the potential for radioactive contaminated fugitive dust generation.

1.0 TITLE: Mitigation of Fugitive Dust.

1.1 APPLICABILITY: This requirement applies to the mechanized soil handling and storage activities (excavation, hauling, and stock piling activities).

1.2 OBJECTIVE: To reduce the potential for fugitive dust generation from soils accumulated during mechanized soil sampling activities.

1.4 REQUIREMENT: Soils accumulated from the mechanized soil washing activities shall be stabilized (i.e., water, fixants, and tarps) if wind speeds exceed 18 km/h (12 mi/h) or if spoils are left unattended (offshift).

1.5 SURVEILLANCE: During activity operations and at the end of the shift, the responsible operating organization shall visually verify that the soil spoils are stabilized. This verification shall be documented in the field log at the end of the shift by the field team leader or the site safety officer.

1.6 RECOVERY:

1.6.1 Noncompliance with the requirement:

1. If the operating organization does not comply with the requirements of this OSL, operations shall immediately cease. The approval of Safety Assurance will be required for restart of operations.

2. Failure to stabilize the soil spoils shall require the responsible operating organization to stabilize the spoils and provide verification before restart of

operations. Concurrence by Independent Safety and line management is also required before restart.

3. The OSL violation shall be documented as an occurrence report.

1.6.2 Noncompliance with the surveillance:

1. The surveillance shall be performed immediately.

2. If surveillance determines noncompliance with the requirements in this OSL, the recovery actions in Section 1.6.1 of this OSL shall be initiated.

3. Failure to execute a surveillance requirement shall be documented as an offnormal occurrence.

1.7 AUDIT POINT: The field log shall be audited weekly to verify compliance with these OSL requirements and surveillance requirements. The results of the audit shall be documented in the field log.

1.8 BASIS: The basis for this requirement is to assure soil spoils subjected to winds speeds greater than 18 km/h (12 mi/h) (the wind speed required for soil particles small enough to be resuspended), or if spoils are left unattended will not result in resuspension of any radioactive contaminants. This limit applies to soils excavated from trenches, pits, solid waste disposal sites, or other areas.

Operational Safety Limit - 2

This OSL applies to storage of contaminated soils and effluent liquids from soil washing activities.

2.0 TITLE: Onsite Storage of Contaminated Soil and Effluent Liquid.

2.1 APPLICABILITY: This OSL applies to any onsite storage of soil or liquid contaminated with hazardous material generated by the soil washing equipment and activities (described in Section 2.0 of this assessment).

2.2 OBJECTIVE: To minimize the potential for releasing contaminated fugitive dusts and liquids to the environment.

2.3 REQUIREMENTS: Contaminated soil and waste liquids must be stored or disposed of in a manner that assures temperature and atmospheric extremes will not cause a release of contaminated material (above regulatory requirements) to the environment. Onsite storage of contaminated soil and liquids must comply with applicable regulations determined by Environmental Assurance and

Independent Safety. Containment of concentrated contaminated sludge material is required during storage or disposal activities.

2.4 SURVEILLANCE: The HWOP, JSA, and RWP requires that contaminated soil and liquid material be maintained to minimize the potential for release to the environment. The HWOP, JSA, and RWP also require stored soil and liquid in containment units be assessed periodically and appropriate action taken, if necessary.

2.5 RECOVERY:

2.5.1 Noncompliance with the requirements:

If these OSL requirements are not complied with, the contaminated soil and liquid material shall be promptly stabilized to the satisfaction of the Site Safety officer. The OSL violation shall be reviewed by the site field team leader, safety officer, and Independent Safety who will jointly determine additional recovery actions, if any. The OSL violation shall be documented as an occurrence report.

2.5.2 Noncompliance with surveillance requirements:

If these surveillance requirements are not complied with, an assessment shall be performed immediately. If noncompliance is determined, then recovery actions in paragraph 2.5.1 of this OSL shall be initiated. Failure to implement surveillance requirements shall be documented as an offnormal occurrence.

2.6 AUDIT POINT: An audible field logbook shall be maintained at the site documenting the results of the surveillance. This log shall be reviewed weekly by the operating organization to assure compliance with the OSL requirements and surveillance requirements. Other audit points are the HWOP, JSA, RWP, and Environmental Engineering surveillances.

2.7 BASIS: The release of contaminated soil or liquid to the environment must be minimized ALARA to reduce the potential effect to the public, the facility workers, and the environment.

4.2 PRUDENT ACTIONS

The following prudent actions will assure that contamination control is maintained, potential hazards are removed, and ALARA goals are met.

Function 1 - Remove contaminated equipment from the soil washing activity site.

Prudent Action 1 - Even though radioactive contamination is expected to be minimal, equipment removed from the activity site will be decontaminated and controlled in accordance with WHC requirements.

Function 2 - Develop a disposal plan for storage of contaminated solid fine soil and liquid material.

Prudent Action 2 - Develop a disposal plan within three months after receiving the final analytical report of the treatability test. Implement the plan as necessary to remove the hazardous material risk.

Function 3 - Mitigate fugitive dust emissions at the loading hopper area.

Prudent Action 3 - If fugitive dust is observed, minimize dust emissions with wind screens around the loading hopper area.

Function 4 - Minimize purgewater contaminants to the environment.

Prudent Action 4 -If the evaporation option is used, effluent processed by the soil washing method must meet purgewater criteria (or as directed by the State Department of Health) for discharge back to soils before forced or solar evaporation.

Function 5 - Test soil washing activities.

Prudent Action 5 - Conduct soil washing activities in accordance with the appropriate HWOP, JSA, RWP, and WHC-CM-7-7 requirements.

5.0 REFERENCES

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APPENDIX A

CRITICALITY EVALUATION OF THE 316-5 PROCESS TRENCHES

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From: Reactor Physics and Special Studies
Phone: 6-4669 HO-38
Date: January 13, 1992
Subject: 300 AREA TRENCH ASSAY INTERPRETATION

To: W. E. Taylor B1-35

cc: D. L. Harrold B1-35
G. C. Henckel, H4-55
H. Toffer HO-38
W. D. Wittekind HO-38
ADW-File/LB 9202

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1. Memo, H. Toffer to G. L. Smith, "Criticality Evaluation of 300 Area Trench," August 1, 1991.

2. DOE/TIC-11026, "Radioactive Decay Data Tables," D. C. Kocher, ORNL, 1981.

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The assay results from the 300 Area process trenches indicate uranium enrichments in U-235 in the range of 2 to 3 wt%. These results are attributed to the failure to account for the uranium isotope U-236 which has built up in the uranium fuel during preceding cycles of reactor exposure combined with reprocessing and reuse. The best estimate of the enrichment of the uranium in the process trenches is 0.988 wt% from the Reference 1 memo.

It is estimated that the amount of uranium in the trench soil is about 720 kg (Reference 1). This is less than half the safe mass of 1,500 kg for 1.25 wt% uranium enrichment in solutions (Reference 1), and cannot be made critical.

BACKGROUND AND ANALYSIS

The 300 Area trenches were put into use in March of 1975. They received mostly uranium bearing process solutions from the N Reactor fuel fabrication facility. Some limited amounts of solutions containing depleted uranium were added by the Pacific Northwest Laboratory.

The process effluent system was modified in 1987 by adding ion exchangers and filters to reduce the chemical and particulate discharge to the process trenches. As a result of the cessation of N Reactor fuels manufacturing, this system was never used.

The uranium in the weirbox was recovered in 1987. The uranium concentrations in the trench were too low for feasible recovery.

It is our understanding that the heavy material in the soil will be partitioned to reduce the volume and the costs of disposing of it.

The trenches were cleaned up in 1991 and the material assayed with the results included in Attachment 1 to this memo. The indicated activities of U-235 and U-238 were converted to concentrations as shown in Table 1 using the specific activities of the two uranium isotopes. For this analysis, it was assumed that the U-238 was equal to the total uranium. This approximation will be accurate to within about 1%.

The U-238 concentration at several locations in the trench were calculated and are recorded in Table 2 for several locations with respect to the discharge to the trench. The design of the weirbox and trench, and the turbulence of the liquid stream tended to minimize the deposition of the uranium particulates in the first 20 meters of the trench. The maximum deposition occurred at about 20 meters from the point of discharge into the trench.

DISCUSSION

The expected uranium enrichment in the 300 Area process trench is 0.988 wt% U-235, Reference 1. As shown in Table 1, the ratios predicted by the alpha counts are generally higher than this by a substantial amount. The ratios calculated from the gamma counting method tend to be in the range of 0.0108 which is also higher than expected.

The total amount of uranium in the trench is reported as 720 kg in Reference 1, while the safe mass for uranium enriched to 1.25 wt% in U-235 in solutions is reported as 1,500 kg. The average effective enrichment of the uranium in the trench is reported as 0.988 wt%, Reference 1. Thus, the safe mass would be larger. The net result is that the uranium in the trench cannot become critical even under the most conservative assumptions.

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Table 1. Apparent Enrichment of Uranium in 300 Area Process Trench

Assay I. D.	Activity Type	Isotopic Activity (pCi/gm) U-235*	U-238	U-235/U-238 Atomic Ratio
B01032	Alpha	1.7	9.2	0.0291
	Gamma	69.52	0.9821	11.15**
B01033	Alpha	74.0	360.0	0.0324
	Gamma	30.79	448.0	0.0108
B01034	Alpha	320.0	2900.0	0.0174
	Gamma	219.3	3196.0	0.0108
B01035	Alpha	9.2	50.0	0.0290
	Gamma	2.074	26.4	0.0123
B01036	Alpha	140.0	1070.0	0.0206
	Gamma	84.64	1246.0	0.0107
B01038	Alpha	1600.0	6030.0	0.0418
	Gamma	638.4	9143.0	0.0110
B01040	Alpha	380.0	9130.0	0.0066
	Gamma	691.0	9659.0	0.0113
B01041	Alpha	2.1	8.6	0.0385
	Gamma	0.3918	4.33	0.0143
B01042	Alpha	7.4	33.0	0.0353
	Gamma	3.013	46.01	0.0103
B01043	Alpha	10.0	77.0	0.0205
	Gamma	8.784	129.6	0.0107
B01044	Alpha	2.9	30.0	0.0152
	Gamma	1.717	26.74	0.01011
B01045	Alpha	0.68	4.3	0.0249
	Gamma	--	--	--
B01046	Alpha	4.2	69.0	0.0096
	Gamma	3.443	53.18	0.0102

*This activity includes the U-236 activity.
**This ratio is in error, perhaps due to incorrect data transcription.

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Table 2 Apparent Uranium Concentrations in 300 Area Process Trench.

Assay I. D.	Distance meters (ft)	Depth meters (ft)	Concentration (gm U-238/gm)
B01034	0.0	0.0	8.63E-03
B01033	0.0	1 (3.0)	1.07E-03
B01040	20.0 (65.6)	0.0	2.72E-02
B01036	20.0 (65.6)	1 (3.0)	3.18E-03
B01043	100.0 (328)	0.0	2.29E-04
B01042	100.0 (328)	1 (3.0)	9.82E-05
B01046	400.0 (1310)	0.0	2.05E-04
B01045	400.0 (1310)	1 (3.0)	1.28E-05

Notes:
1. The distance is measured from the point of discharge into the trench.
2. The depth is the sample depth into the trench bottom.
3. The samples have been concentrated into about 3% of the original soil volume.

The quantity of uranium in the trench reported as 720 kg (Reference 1) was from the Table 2 data.

It is noted that the sampling technique used to measure the uranium activity concentrated the uranium into about 3% of the original soil volume.

The overestimate of the U-235 concentration based on the alpha response is due to a failure to differentiate between the alpha particles from U-235 and those from U-236. Alpha particles are emitted from U-236 with three major energies in the range from 4,332 keV to 4,494 keV. The alpha particles from U-235 have energies in 14 major groups ranging from 4,150 keV to 4,598 keV. These energies are shown in Attachment 2, from the Nuclear Data Tables, Reference 2. The uranium isotope U-236 is present in very small trace amounts in recycled uranium, if at all. When uranium is irradiated, there is competition between capture and fission in U-235 which results in a buildup of U-236 in the uranium resulting from non-fission capture. The unburned uranium in the N Reactor fuel was recovered during the plutonium separation process and recycled into the N Reactor fuel. The U-236 has a shorter half-life than the U-235 so that the specific activity is greater. The half-life for U-235 is 7.04×10^8 years, while the half-life of U-236 is 2.34×10^7 years. The specific activity of each isotope is proportional to the inverse of its half-life. Thus, the U-236 is $7.04 \times 10^8 / 2.34 \times 10^7 = 30$ times as active as U-235 for the same number of grams (or atoms) of each isotope. It is calculated that for about 640 ppm of U-236 combined with 1 wt% U-235 in the uranium fuel, the activity would be equivalent to a U-235 enrichment of 2.9 wt%. This is the apparent enrichment of the uranium at the first entry in Table 1. It is noted that UNI-489, Reference 3, used a U-236 content of 0.04 wt% (= 400 ppm) and that further recycle of the N Reactor uranium would increase this U-236 content. The composition table from UNI-489 is included as Attachment 3 to this memo.

It is noted that for unirradiated uranium that is used for commercial power reactor fuel, there will be no U-236 present and the alpha spectroscopy will produce acceptable accuracy for U-235 assays.

The difference between the 1.08 wt% calculated from the gamma spectral analysis and the 0.988 wt% in Reference 1 is attributed primarily to uncertainties in the gamma spectroscopy with minor contributions from uncertainties in the Reference 1 estimates.

The uncertainty imposed in using the safe mass for 1.25 wt% uranium scrap is conservative because the average enrichment for the uranium in the trench is estimated as 0.998 wt%. There is further conservatism inherent in the safe mass calculations which assume an ideal mixture composed of fuel rods in water with an optimum diameter and spacing.

RECOMMENDATIONS

The best estimate of the enrichment of the uranium in the process trenches is 0.988 wt% from the Reference 1 memo.

The amount of the uranium in the process trenches is 720 kg, as reported in Reference 1. This is a conservative upper limit.

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Date

Reviewed by: Warren D. Wittekind 15 January 1992
W. D. Wittekind, Principal Engineer
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Approved by: _____ 1-16-1992
H. Toffer, Manager
Reactor Physics and Special Studies
Date

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Attachments

ATTACHMENT 1 RESULTS (page 1)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01032	1	7/30-31/91	Gross Alpha	24 ± 10	
			Gross Beta	30 ± 6	
			^{90}Sr	(2 ± 7)	E-01
			^{99}Tc	(3.8 ± 0.2)	E+00
			Total Uranium	(2.8 ± 0.6)	E+01
			^{234}U	(1.3 ± 0.1)	E+01
			^{235}U	(1.7 ± 0.3)	E+00
			^{238}U	(9.2 ± 1.0)	E+00
			^{238}Pu	(1.9 ± 1.5)	E-01
			$^{239,240}Pu$	(1.4 ± 0.5)	E+00
			Gamma Scan:		
			^{40}K	(1.058 ± 0.047)	E+01
			^{60}Co	(2.202 ± 0.322)	E-01
			^{137}Cs	(5.229 ± 0.334)	E-01
			^{226}Ra	(4.213 ± 0.449)	E-01
			^{235}U	(6.952 ± 1.100)	E-01
			^{236}U	(9.821 ± 2.557)	E-01
			^{228}Th	(6.424 ± 0.287)	E-01
			^{232}Th	(5.937 ± 1.114)	E-01
B01033	2	7/30/31/91	Gross Alpha	316 ± 25	
			Gross Beta	454 ± 12	
			^{90}Sr	(1.3 ± 12)	E+00
			^{99}Tc	(9.9 ± 0.3)	E+01
			Total Uranium	(1.0 ± 0.2)	E+03
			^{234}U	(5.2 ± 0.3)	E+02
			^{235}U	(7.4 ± 0.9)	E+01
			^{236}U	(3.6 ± 0.2)	E+02
			^{238}Pu	(7 ± 6)	E-02
			$^{239,240}Pu$	(1.7 ± 0.7)	E-01
			Gamma Scan:		
			^{40}K	(9.295 ± 0.416)	E+00
			^{60}Co	(1.130 ± 0.261)	E-01
			^{137}Cs	(5.534 ± 0.426)	E-01
			^{226}Ra	(4.849 ± 0.581)	E-01
			^{235}U	(3.079 ± 0.028)	E+01
			^{236}U	(4.480 ± 0.076)	E+02
			^{228}Th	(1.533 ± 0.065)	E+00
			^{232}Th	(6.262 ± 1.175)	E-01

ATTACHMENT 1 RESULTS (page 2)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01034	3	7/30-31/91	Gross Alpha	3.12 ± 0.08	E+03
			Gross Beta	5.42 ± 0.05	E+03
			^{90}Sr	(1.5 ± 0.3)	E+01
			^{99}Tc	(7.38 ± 0.09)	E+02
			Total Uranium	(6.7 ± 1.3)	E+03
			^{234}U	(3.9 ± 0.3)	E+03
			^{235}U	(3.2 ± 1.2)	E+02
			^{238}U	(2.9 ± 0.2)	E+03
			^{238}Pu	(2.3 ± 1.4)	E-01
			$^{239,240}Pu$	(1.6 ± 0.5)	E+00
			Gamma Scan:		
			^{40}K	(5.226 ± 0.629)	E+00
			^{60}Co	(5.536 ± 0.712)	E-01
			^{137}Cs	(1.083 ± 0.121)	E+00
			^{226}Ra	(1.244 ± 0.201)	E+00
			^{235}U	(2.193 ± 0.011)	E+02
			^{238}U	(3.196 ± 0.029)	E+03
			^{228}Th	(5.385 ± 0.133)	E+00
			^{232}Th	(1.429 ± 0.251)	E+00
B01035	4	7/30-31/91	Gross Alpha	49 ± 12	
			Gross Beta	66 ± 5	
			^{90}Sr	(2 ± 6)	E-01
			^{99}Tc	(2.25 ± 0.03)	E+03
			Total Uranium	(1.1 ± 0.2)	E+02
			^{234}U	(6.9 ± 0.2)	E+01
			^{235}U	(9.2 ± 1.2)	E+00
			^{238}U	(5.0 ± 0.5)	E+01
			^{238}Pu	(0 ± 6)	E-02
			$^{239,240}Pu$	(0 ± 5)	E-02
			Gamma Scan:		
			^{40}K	(9.417 ± 0.431	E+00
			^{60}Co	(8.216 ± 2.380)	E-02
			^{137}Cs	(3.930 ± 0.291)	E-01
			^{226}Ra	(3.934 ± 0.420)	E-01
			^{235}U	(2.074 ± 0.168)	E+00
			^{238}U	(2.646 ± 0.326)	E+01
			^{228}Th	(5.725 ± 0.272)	E-01
			^{232}Th	(5.938 ± 1.018)	E-01

ATTACHMENT 1 RESULTS (page 3)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01036	5	7/30-31/91	Gross Alpha	1.62 ± 0.06	E+03
			Gross Beta	1.79 ± 0.03	E+03
			^{90}Sr	(6.7 ± 3.6)	E+00
			^{99}Tc	(6.91 ± 0.07)	E+02
			Total Uranium	(2.1 ± 0.4)	E+03
			^{234}U	(1.53 ± 0.08)	E+03
			^{235}U	(1.4 ± 0.3)	E+02
			^{238}U	(1.07 ± 0.06)	E+03
			^{238}Pu	(1.6 ± 0.9)	E-01
			$^{239,240}Pu$	(5.3 ± 1.6)	E-01
			Gamma Scan:		
			^{40}K	(7.921 ± 0.506)	E+00
			^{60}Co	(3.592 ± 0.486)	E-01
			^{137}Cs	(5.280 ± 0.688)	E-01
			^{226}Ra	(4.036 ± 0.917)	E-01
			^{235}U	(8.464 ± 0.055)	E+01
			^{238}U	(1.246 ± 0.015)	E+03
			^{228}Th	<1.286	E-01
			^{232}Th	(8.278 ± 1.782)	E-01
B01038	6	7/30-31/91	Gross Alpha	3.09 ± 0.07	E+03
			Gross Beta	1.12 ± 0.01	E+04
			^{90}Sr	(1.2 ± 0.2)	E+01
			^{99}Tc	(3.60 ± 0.08)	E+03
			Total Uranium	(1.6 ± 0.3)	E+04
			^{234}U	(8.79 ± 0.74)	E+03
			^{235}U	(1.6 ± 0.2)	E+03
			^{238}U	(6.03 ± 0.052)	E+03
			^{238}Pu	(1.2 ± 0.4)	E+00
			$^{239,240}Pu$	(4.1 ± 0.9)	E+00
			Gamma Scan:		
			^{40}K	(2.400 ± 0.659)	E+00
			^{60}Co	(7.881 ± 0.976)	E-01
			^{137}Cs	(8.917 ± 1.383)	E-01
			^{226}Ra	(9.942 ± 2.591)	E-01
			^{235}U	(6.384 ± 0.017)	E+02
			^{238}U	(9.143 ± 0.043)	E+03
			^{228}Th	(1.573 ± 0.020)	E+01
			^{232}Th	(1.751 ± 0.380)	E+00

ATTACHMENT 1 RESULTS (page 4)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01040	8	7/30-31/91	Gross Alpha	4.45 ± 0.09	E+03
			Gross Beta	1.22 ± 0.01	E+04
			^{90}Sr	(1.8 ± 0.7)	E+01
			^{99}Tc	(3.45 ± 0.06)	E+03
			Total Uranium	(2.0 ± 0.4)	E+04
			^{234}U	(1.19 ± 0.11)	E+04
			^{235}U	(3.8 ± 3.0)	E+02
			^{238}U	(9.13 ± 0.84)	E+03
			^{238}Pu	(6 ± 4)	E-01
			$^{239,240}Pu$	(4.7 ± 1.5)	E+00
			Gamma Scan:		
			^{40}K	(3.132 ± 0.917)	E+00
			^{60}Co	(9.625 ± 1.340)	E-01
			^{137}Cs	(1.140 ± 0.150)	E+00
			^{226}Ra	(9.713 ± 3.195)	E-01
			^{235}U	(6.910 ± 0.022)	E+02
			^{238}U	(9.659 ± 0.051)	E+03
			^{228}Th	(1.679 ± 0.038)	E+01
			^{232}Th	(1.656 ± 0.478)	E+00
B01041	9	7/31/91	Gross Alpha	11 ± 8	
			Gross Beta	17 ± 3	
			^{90}Sr	(4 ± 48)	E-02
			^{99}Tc	(1.3 ± 0.4)	E+00
			Total Uranium	(1.6 ± 0.3)	E+01
			^{234}U	(1.3 ± 0.2)	E+01
			^{235}U	(2.1 ± 0.5)	E+00
			^{238}U	(8.6 ± 1.2)	E+00
			^{238}Pu	(0 ± 6)	E-02
			$^{239,240}Pu$	(0 ± 7)	E-02
			Gamma Scan:		
			^{40}K	(9.360 ± 0.388)	E+00
			^{60}Co	(8.434 ± 2.272)	E-02
			^{137}Cs	(3.751 ± 1.315)	E-02
			^{226}Ra	(3.898 ± 0.365)	E-01
			^{235}U	(3.918 ± 0.764)	E-01
			^{238}U	(4.330 ± 2.477)	E+00
			^{228}Th	(5.627 ± 0.227)	E-01
			^{232}Th	(5.624 ± 0.866)	E-01

ATTACHMENT 1 RESULTS (page 5)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01042	10	7/30-31/91	Gross Alpha	63 ± 13	
			Gross Beta	120 ± 7	
			^{90}Sr	(6 ± 9)	E-01
			^{99}Tc	(2.2 ± 0.1)	E+01
			Total Uranium	(6.2 ± 1.2)	E+01
			^{234}U	(4.6 ± 0.7)	E+01
			^{235}U	(7.4 ± 1.4)	E+00
			^{238}U	(3.3 ± 0.5)	E+01
			^{238}Pu	(0 ± 2)	E-01
			$^{239,240}Pu$	(0 ± 1)	E-01
			Gamma Scan:		
			^{40}K	(9.652 ± 0.497)	E+00
			^{60}Co	(6.691 ± 2.448)	E-02
			^{137}Cs	(3.407 ± 0.325)	E-01
			^{226}Ra	(3.818 ± 0.467)	E-01
			^{235}U	(3.013 ± 0.177)	E+00
			^{238}U	(4.601 ± 0.406)	E+01
			^{228}Th	(6.550 ± 0.445)	E-01
			^{232}Th	(6.510 ± 1.184)	E-01
B01043	11	7/30-31/91	Gross Alpha	24 ± 8	
			Gross Beta	37 ± 4	
			^{90}Sr	(4 ± 10)	E-01
			^{99}Tc	(2.70 ± 0.08)	E+01
			Total Uranium	(1.4 ± 0.3)	E+02
			^{234}U	(1.1 ± 0.1)	E+02
			^{235}U	(1.0 ± 0.3)	E+01
			^{238}U	(7.7 ± 1.0)	E+01
			^{238}Pu	(2.2 ± 0.8)	E-01
			$^{239,240}Pu$	(2.0 ± 0.8)	E-01
			Gamma Scan:		
			^{40}K	(8.846 ± 0.473)	E+00
			^{60}Co	(1.369 ± 0.317)	E-01
			^{137}Cs	(6.079 ± 0.441)	E-01
			^{226}Ra	(4.020 ± 0.595)	E-01
			^{235}U	(8.784 ± 0.200)	E+00
			^{238}U	(1.296 ± 0.061)	E+02
			^{228}Th	(8.045 ± 0.604)	E-01
			^{232}Th	(5.658 ± 1.122)	E-01

ATTACHMENT 1 RESULTS (page 6)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01044	12	7/30-31/91	Gross Alpha	19 ± 8	
			Gross Beta	38 ± 4	
			^{90}Sr	(4 ± 2)	E-01
			^{99}Tc	(1.3 ± 0.1)	E+01
			Total Uranium	(7.5 ± 1.5)	E+01
			^{234}U	(4.2 ± 0.4)	E+01
			^{235}U	(2.9 ± 1.3)	E+00
			^{238}U	(3.0 ± 0.3)	E+01
			^{238}Pu	(6 ± 5)	E-02
			$^{239,240}Pu$	(9 ± 5)	E-02
			Gamma Scan:		
			^{40}K	(9.560 ± 0.434)	E+00
			^{60}Co	(3.088 ± 0.301)	E-01
			^{137}Cs	(6.851 ± 0.360)	E-01
			^{226}Ra	(4.223 ± 0.490)	E-01
			^{235}U	(1.717 ± 0.154)	E+00
			^{238}U	(2.674 ± 0.317)	E+01
			^{228}Th	(6.154 ± 0.290)	E-01
			^{232}Th	(5.833 ± 1.015)	E-01
B01045	13	7/30-31/91	Gross Alpha	8 ± 7	
			Gross Beta	14 ± 4	
			^{90}Sr	(2 ± 6)	E-01
			^{99}Tc	(1.2 ± 0.1)	E+01
			Total Uranium	(1.2 ± 0.2)	E+01
			^{234}U	(5.7 ± 0.7)	E+00
			^{235}U	(6.8 ± 1.8)	E-01
			^{238}U	(4.3 ± 0.6)	E+00
			^{238}Pu	(0 ± 8)	E-02
			$^{239,240}Pu$	(0 ± 6)	E-02
			Gamma Scan:		
			^{40}K	(9.162 ± 0.442)	E+00
			^{60}Co	(4.497 ± 2.085)	E-02
			^{137}Cs	(3.440 ± 0.214)	E-01
			^{226}Ra	(4.342 ± 0.419)	E-01
			^{228}Th	(5.178 ± 0.250)	E-01
			^{232}Th	(5.178 ± 0.930)	E-01

ATTACHMENT 1 RESULTS (page 7)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01046	14	7/30-31/91	Gross Alpha	55 ± 11	
			Gross Beta	81 ± 5	
			^{90}Sr	(6 ± 21)	E-01
			^{99}Tc	(2.4 ± 0.4)	E+01
			Total Uranium	(1.5 ± 0.3)	E+02
			^{234}U	(8.7 ± 0.7)	E+01
			^{235}U	(4.2 ± 2.5)	E+00
			^{238}U	(6.9 ± 0.6)	E+01
			^{238}Pu	(0 ± 2)	E-01
			$^{239,240}Pu$	(3.0 ± 2.3)	E-01
			Gamma Scan:		
			^{40}K	(1.207 ± 0.053)	E+01
			^{60}Co	(1.034 ± 0.051)	E+00
			^{137}Cs	(1.067 ± 0.048)	E+00
			^{226}Ra	(5.547 ± 0.628)	E-01
			^{235}U	(3.443 ± 0.217)	E+00
			^{238}U	(5.318 ± 0.594)	E+01
			^{228}Th	(7.128 ± 0.311)	E-01
			^{232}Th	(6.739 ± 1.367)	E-01

ATTACHMENT 2 QA/QC RESULTS (Page 1)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01032	1	7/30-31/91	Gross Alpha	24 ± 10	
			Gross Beta	30 ± 6	
			^{90}Sr	(2 ± 7)	E-01
			^{99}Tc	(3.8 ± 0.2)	E+00
			Total Uranium	(2.8 ± 0.6)	E+01
			^{234}U	(1.3 ± 0.1)	E+01
			^{235}U	(1.7 ± 0.3)	E+00
			^{238}U	(9.2 ± 1.0)	E+00
			^{238}Pu	(1.9 ± 1.5)	E-01
			$^{239,240}Pu$	(1.4 ± 0.5)	E+00
			Gamma Scan:		
			^{40}K	(1.058 ± 0.047)	E+01
			^{60}Co	(2.202 ± 0.322)	E-01
			^{137}Cs	(5.229 ± 0.334)	E-01
			^{226}Ra	(4.213 ± 0.449)	E-01
			^{235}U	(6.952 ± 1.100)	E-01
			^{238}U	(9.821 ± 2.557)	E-01
			^{228}Th	(6.424 ± 0.287)	E-01
			^{232}Th	(5.937 ± 1.114)	E-01
B01032	15	7/30-31/91	Gross Alpha	13 ± 8	
			Gross Beta	23 ± 5	
			^{90}Sr	(-6 ± 57)	E-02
			^{99}Tc	(2.2 ± 0.2)	E+00
			Total Uranium	(2.5 ± 0.5)	E+01
			^{234}U	(1.2 ± 0.1)	E+01
			^{235}U	(1.7 ± 0.3)	E+00
			^{238}U	(9.0 ± 1.0)	E+00
			^{238}Pu	(0 ± 6)	E-02
			$^{239,240}Pu$	(2.7 ± 1.0)	E-01
			Gamma Scan:		
			^{40}K	(1.001 ± 0.048)	E+01
			^{60}Co	(1.987 ± 0.304)	E-01
			^{137}Cs	(4.751 ± 0.346)	E-01
			^{226}Ra	(4.168 ± 0.447)	E-01
			^{235}U	(7.590 ± 1.130)	E-01
			^{238}U	(1.107 ± 0.293)	E+01
			^{228}Th	(6.172 ± 0.299)	E-01
			^{232}Th	(5.714 ± 1.139)	E-01

ATTACHMENT 2 QA/QC RESULTS (Page 2)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01046	14	7/30-31/91	Gross Alpha	55 ± 11	
			Gross Beta	81 ± 5	
			^{90}Sr	(6 ± 21)	E-01
			^{99}Tc	(2.4 ± 0.4)	E+01
			Total Uranium	(1.5 ± 0.3)	E+02
			^{234}U	(8.7 ± 0.7)	E+01
			^{235}U	(4.2 ± 2.5)	E+00
			^{238}U	(6.9 ± 0.6)	E+01
			^{238}Pu	(0 ± 2)	E-01
			$^{239,240}Pu$	(3.0 ± 2.3)	E-01
			Gamma Scan:		
			^{40}K	(1.207 ± 0.053)	E+01
			^{60}Co	(1.034 ± 0.051)	E+00
			^{137}Cs	(1.067 ± 0.048)	E+00
			^{226}Ra	(5.547 ± 0.628)	E-01
			^{235}U	(3.443 ± 0.217)	E+00
			^{238}U	(5.318 ± 0.594)	E+01
			^{228}Th	(7.128 ± 0.311)	E-01
			^{232}Th	(6.739 ± 1.367)	E-01
B01046	16	7/30-31/91	Gross Alpha	58 ± 13	
			Gross Beta	110 ± 7	
			^{90}Sr	(4.0 ± 2.5)	E-01
			^{99}Tc	(2.3 ± 0.1)	E+01
			Total Uranium	(1.8 ± 0.4)	E+02
			^{234}U	(8.5 ± 0.8)	E+01
			^{235}U	(6.0 ± 2.0)	E+00
			^{238}U	(6.2 ± 0.6)	E+01
			^{238}Pu	(0 ± 8)	E-02
			$^{239,240}Pu$	(0 ± 8)	E-02
			Gamma Scan:		
			^{40}K	(9.528 ± 0.440)	E+00
			^{60}Co	(8.887 ± 0.457)	E-01
			^{137}Cs	(1.045 ± 0.040)	E+00
			^{226}Ra	(5.524 ± 0.577)	E-01
			^{235}U	(2.934 ± 0.156)	E+00
			^{238}U	(4.510 ± 0.404)	E+01
			^{228}Th	(7.128 ± 0.318)	E-01
			^{232}Th	(7. 9 ± 1.398)	E-01

From: Reactor Physics and Special Studies
Phone: 6-2894 HO-38
Date: August 1, 1991
Subject: CRITICALITY EVALUATION OF 300 AREA TRENCHES

To: G. L. Smith L4-75

cc: P. C. Doto R3-01
N. R. Kerr B1-35
A. E. Waltar HO-32
A. D. Wilcox HO-38
HT-File/LB 9142

References:

1. WHC-CM-4-29, Nuclear Criticality Safety Manual, "Criticality Engineering Analysis," September 15, 1988.

2. Nuclear Criticality Safety Theory and Practice, R. A. Knief, American Nuclear Society, p. 69, 1985.

3. WHC-SP-0193, 300 Area Process Trench Report, December 1987.

4. Criticality Safety of Uranium Metal Scrap in Concrete Billets, American Nuclear Society Transactions, H. Toffer and E. A. Weakley, Vol. 15, Number 1, p. 310-311, June 1972.

SUMMARY

The enrichment, the form, and the amount of uranium in a multi-material matrix makes criticality impossible in the 300 Area process trenches and during subsequent handling of the uranium bearing material.

DETAILS OF ANALYSIS

A detailed assessment of subcriticality for the trench material was performed. The evaluation relied extensively on past analyses and measurements. The evaluation approach considered: an assessment of the average enrichment of the material; nuclear criticality of the uranium in various forms at that enrichment; the impact of the matrix material on criticality; and nuclear criticality for hypothetical scenarios.

The 300 Area trenches were put in use in March of 1975. They received mostly uranium bearing process solutions from the N Reactor fuel fabrication facility. Some limited amounts of solutions containing depleted uranium were added by the Pacific Northwest Laboratory. The concentration of uranium in the trenches (approximately 0.03 g/cc) was too low for any mining considerations and well below concentrations at which neutron multiplication constants would be a maximum (Reference 4).

ENRICHMENT OF THE URANIUM

If the assumption is made that the uranium is typical of the N Reactor fuel, then an average enrichment based on N Reactor throughput can be developed. Considering that the N Reactor is loaded with 300 spike fuel 701 base metal, and 2 natural uranium metal fuel charges:

Spike fuel charge	384 lb	0.947 wt% enriched U
	360 lb	1.25 wt% enriched U
Base charge MKIV	816 lb	0.947 wt% enriched U
Natural charge MKIVB	816 lb	0.72 wt% enriched U

Based on the above listed inventories, an effective enrichment of 0.988 wt% is calculated. This agrees with some enrichment measurements of 0.94 wt% U-235 in uranium of the material in the trench according to E. A. Weakley. Any addition of depleted uranium bearing wastes would lower the 0.988 wt% value. The fact that the effective enrichment of the uranium in the trenches is 1.0 or less has important ramifications on nuclear criticality considerations.

NUCLEAR CRITICALITY OF THE URANIUM IN VARIOUS FORMS

Since the average uranium enrichment of the material in the trenches was determined to be less than 1.0 wt% U-235 in uranium, and all sampling indicates a homogeneous distribution of uranium in the matrix, certain nuclear criticality limits can be established.

Uranium homogeneously distributed in water at optimum moderation with a 1.03 wt% enrichment can not be made critical. In other words, the material has an infinite critical mass. If the uranium assumes some heterogeneous forms, the critical mass for 1.0 wt% uranium will become finite, and according to Reference 2, is 2300 lb (optimum size rods water reflected and optimally moderated). It is highly improbable that the uranium would assume an optimum heterogeneous configuration.

IMPACT OF THE MATRIX MATERIAL ON NUCLEAR CRITICALITY

Reference 3 indicates that the uranium in the trenches is mixed homogeneously with a variety of other elements, mostly metals such as copper, nickel, chromium, etc. Each one of these constituents in a mixture will tend to make the uranium more subcritical or increase critical masses. No explicit calculations were performed, but results in Reference 4 show that small amounts of contaminants have significant impact on critical masses and k-inf values. The reference compares uranium distributed uniformly in water and in concrete, both as a homogeneous mixture and a heterogenous distribution. In either case, the matrix material decreases k-inf values substantially. The effective enrichment of homogeneously distributed uranium in concrete that can be made critical is approximately 1.6 wt%, whereas the value for water is 1.03 wt%. The value for uranium nitrate is 2.1 wt% Any presence of matrix material will make uranium systems be more subcritical.

NUCLEAR CRITICALITY FOR HYPOTHETICAL SCENARIOS

An unrealistic hypothetical scenario can be postulated that assumes all the uranium is of the highest enrichment and that it is in a homogeneous distribution at optimum conditions of moderation and reflection. In Reference 3, a value of total amount of uranium in the trenches was quoted as 720 kg. The safe mass for 1.25 wt% enriched uranium in solution is 3300 lb or 1500 kg uranium (see Reference 2).

It is assumed that all the uranium would become heterogeneously distributed throughout the trench material with optimum moderation and reflection and no matrix materials present. The minimum critical mass would be 2300 kg for 1 wt% and 750 kg for 1.25 wt% uranium enrichment.

CONCLUSION

The uranium present in the trench material has an enrichment that is too low for potential criticality. It is in a homogeneous form and the total mass of uranium is insufficient to support a self-sustaining chain reaction, even under the worst case assumptions. Therefore, it is safe to handle the material from a nuclear criticality perspective.

G. L. Smith
Page 4
August 1, 1991

According to Reference 1, uranium homogeneously distributed in a matrix and having a uranium enrichment of less than or equal to 1 wt% U-235, as well as facilities containing such matrices, are exempt from criticality controls.

Hans Toffer

Hans Toffer, Manager
Reactor Physics and Special Studies

CONCURRENCE: P. C. Doto

P. C. Doto, Manager
Criticality Engineering Analysis

kls

ATTACHMENT 2

Radiation Type	Energy (keV)	Intensity (%)	Δ(p-rad/μCi-h)
• ^{234}Pa β⁻ Decay (1.17 m 3) %β Decay = 99.840 18 Feeds ^{234}U See also ^{234}Pa IT Decay (1.17 m)		I (min) = 0.10%	
Auger-L	9.89	0.35 5	≈0
ce-L- 1	21.723 10	0.476 15	0.0002
ce-KMO- 1	37.932 10	0.1783	0.0001
ce-K- 66	694.4 7	0.3992	0.0059
β⁻ 1 max	1236 5		
avg	410.2 19	0.74	0.0065
β⁻ 2 max	1471 5		
avg	500.8 20	0.62	0.0066
β⁻ 3 max	2281 5		
avg	825.4 21	98.6	1.73
total β⁻ avg	819.2 21	100.14782	1.75
19 weak β's omitted: Eβ(avg)= 208.8; ΣIβ= 0.19%			
I-ray L	13.6	0.84 5	0.0001
I-ray $Kα_2$	94.6650 20	0.115 2	0.0002
I-ray $Kα_1$	98.4390 20	0.187 4	0.0004
γ 57	766.410 20	0.207 8	0.0034
γ 82	1001.03 3	0.5890 1	0.0126
125 weak γ's omitted: Eγ(avg)= 926.2; ΣIγ= 0.37%			
• ^{234}U α Decay (2.445E5 y 10) Feeds ^{230}Th % Spontaneous Fission = 1.2E−9 6		I (min) = 0.10%	
Auger-L	9.48	9.7 14	0.0020
ce-L- 1	32.73 5	20.1 18	0.0180
ce-K- 1	48.02 5	5.5 5	0.0056
ce-KOP- 1	51.87 5	2.02 19	0.0022
ce-L- 2	100.428 20	0.139 15	0.0003
α 1	4604.7 20	0.24 3	0.0235
α 2	4723.7 20	27.4 15	2.76
α 3	4775.8 20	72.4 20	7.36
I-ray L	13	10.5 14	0.0029
γ 1	53.20 5	0.118 10	0.0001
9 weak γ's omitted: Eγ(avg)= 121.4; ΣIγ= 0.04%			
• ^{235}U α Decay (7.038E8 y 5) Feeds ^{231}Th % Spontaneous Fission < 4.2E−8		I (min) = 0.10%	
Auger-L	9.48	29 10	0.0058
ce-L- 2	11.0779 5	18 19	0.0042
ce-KMO- 1	14.4077 3	68 8	0.0209
ce-L- 3	20.9 3	1.2 8	0.0005
ce-L- 4	21.89 15	19.6 10	0.0090
ce-KMO- 2	26.3677 3	7 7	0.0037

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/ μCi-h)
• ^{235}Np EC Decay (396.1 d 12)		I (min) = 0.10%	
%EC Decay = 99.9986 2			
Feeds ^{235}U			
%α Decay = 0.0014 2			
Auger-L	9.89	30 4	0.0062
X-ray L	13.6	38 5	0.0109
X-ray $Kα_2$	94.6650 20	0.51 15	0.0010
X-ray $Kα_1$	98.4390 20	0.83 24	0.0017
X-ray Kβ	111	0.39 11	0.0009
• ^{236}U α Decay (2.3415E7 y 14)		I (min) = 0.10%	
Feeds ^{232}Th			
Auger-L	9.48	9.2 17	0.0019
ce-L- 1	28.897 9	19 3	0.0117
ce-MNO- 1	44.187 9	6.9 11	0.0065
ce-L- 2	92.278 15	0.159 7	0.0003
α 1	4332 8	0.260 10	0.0240
α 2	4445 5	26 4	2.46
α 3	4494 3	74 4	7.08
X-ray L	13	10.0 18	0.0028
2 weak γ's omitted: Σγ (avg) = 68.2; ΣIγ = 0.11%			
• ^{236}Np EC Decay (1.15E5 y 12)		I (min) = 0.10%	
%EC Decay = 91.1 20			
Feeds ^{236}U			
See also ^{236}Np $β^-$ Decay (1.15E5 y)			
Auger-L	9.89	103 15	0.0217
ce-L- 1	23.485 6	66.6 16	0.0333
ce-MNO- 1	39.694 6	24.4 8	0.0206
ce-K- 3	44.704 9	5.85 22	0.0056
Auger-K	72.6	1.6 12	0.0020
ce-L- 2	82.476 5	60.6 15	0.106
ce-M- 2	98.685 5	16.8 6	0.0352
ce-MCP- 2	102.792 5	6.32 23	0.0138
ce-L- 3	138.553 8	31.7 12	0.0937
ce-M- 3	154.762 8	8.8 4	0.0290
ce-MOP- 3	158.869 8	3.28 13	0.0111
X-ray L	13.6	131 15	0.0380
γ 1	45.242 6	0.152 6	0.0001
X-ray $Kα_2$	94.6650 20	20.7 5	0.0417
X-ray $Kα_1$	98.4390 20	33.6 7	0.0703
γ 2	104.233 5	7.47 25	0.0166
X-ray Kβ	111	15.6 4	0.0369
γ 3	160.310 8	27.6 6	0.0943

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/ μCi-h)
ce-L- 5	30.83 10	4 3	0.0027
ce-L- 6	33.6279 5	1.74 22	0.0012
ce-K- 16	34.109 20	1.72 15	0.0013
ce-KLO- 3	36.2 3	0.4 3	0.0003
ce-KMO- 4	36.78 15	6.7 5	0.0052
ce-K- 18	41.289 20	0.20 19	0.0002
ce-L- 5	46.12 10	1.1 9	0.0011
ce-K- 6	48.9177 3	0.45 7	0.0005
ce-MOP- 5	49.97 10	0.4 3	0.0004
ce-L- 7	52.23 20	4.15 13	0.0046
ce-MOP- 6	52.7705 4	0.163 24	0.0002
ce-K- 19	53.699 20	0.57 6	0.0007
ce-K- 7	67.52 20	1.13 4	0.0016
Auger-K	69.2	0.23 16	0.0003
ce-MOP- 7	71.37 20	0.419 13	0.0006
ce-K- 22	73.05 20	0.6 6	0.0009
ce-K- 23	74.064 5	4.96 15	0.0078
ce-L- 10	75.618 20	0.87 12	0.0014
ce-L- 11	88.668 20	0.107 15	0.0002
ce-KMO-10	90.908 20	0.33 5	0.0006
ce-K- 26	92.469 20	1.1 10	0.0022
ce-K- 27	95.660 10	0.33 3	0.0007
ce-L- 13	99.5279 5	0.521 7	0.0011
ce-KMO-13	114.8177 3	0.196 5	0.0005
ce-L- 16	123.288 20	0.37 3	0.0010
ce-KMO-16	138.578 20	0.120 10	0.0004
ce-L- 19	142.878 20	0.118 11	0.0004
ce-L- 22	162.23 20	0.22 3	0.0008
ce-L- 23	163.243 5	1.00 3	0.0035
ce-KMO-23	178.533 5	0.3278 8	0.0012
ce-L- 26	181.648 20	0.38 5	0.0015
ce-KMO-26	196.938 20	0.133 14	0.0006
α 1	4150 5	0.90 20	0.0796
α 2	4217 3	5.7 6	0.512
α 3	4219 6	0.9	0.0809
α 4	4271 5	0.4	0.0364
α 5	4325	4.6 5	0.424
α 6	4344	1.5	0.139
α 7	4364 5	11	1.02
α 8	4370 4	6	0.558
α 9	4396 3	55 3	5.15
α 10	4414 4	2.10 20	0.197
α 11	4435 5	0.7	0.0661
α 12	4502.0 20	1.70 20	0.163
α 13	4556.0 20	4.2 3	0.408
α 14	4598.0 20	5.0 5	0.490
I-ray L	13	31 11	0.0086
γ 7	72.70 20	0.1	0.0002
I-ray Ka_2	89.9530 20	2.7 4	0.0052
I-ray Ka_1	93.3500 20	4.5 6	0.0089
I-ray Kβ	105	2.1 3	0.0046
γ 11	109.140 20	1.50 20	0.0035
γ 13	120	0.15	0.0004
γ 15	140.77 8	0.22 3	0.0007
γ 16	143.760 20	10.5 8	0.0322
γ 19	163.350 20	4.7 4	0.0164
γ 22	182.70 20	0.40 5	0.0016
γ 23	183.715 5	54	0.211
γ 24	194.940 10	0.59 6	0.0024
γ 26	202.120 20	1.00 10	0.0043
γ 27	205.311 10	4.7 4	0.0206
γ 29	221.380 20	0.100 10	0.0005

42 weak γ's omitted:
E_γ(avg)= 190.3; ΣI_γ= 0.92%

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/ μCi-h)
• ^{236}Np β^- Decay (1.15E5 y 12)		I (min) = 0.10%	
%β^- Decay = 8.9 20			
Feeds ^{236}Pu			
See also ^{236}Np EC Decay (1.15E5 y)			
Auger-L	10.3	5.9 15	0.0013
ce-L- 1	21.50 10	6.5 15	0.0030
ce-K- 3	38 6	0.3 3	0.0002
ce-MNO- 1	38.67 10	2.4 6	0.0020
ce-L- 2	77 3	6.0 14	0.0099
ce-M- 2	94 3	1.7 4	0.0034
ce-MOP- 2	98 3	0.65 15	0.0014
ce-L- 3	137 6	2.0 21	0.0058
ce-M- 3	154 6	0.6 6	0.0018
ce-MOP- 3	158 6	0.21 22	0.0007
β^- 1 max	195 5		
avg	52.3 15	5 5	0.0056
β^- 2 max	355 3		
avg	105.6 9	5 5	0.0112
total β^-			
avg	78.9 15	10 7	0.0168
X-ray L	14.3	8.8 20	0.0027
γ 2	100 3	0.52 12	0.0011
X-ray $K\alpha_1$	103.76 5	0.13 14	0.0003
γ 3	160 6	1.4 15	0.0049
1 weak γ's omitted:			
$\Sigma E\gamma$(avg)= 44.6; $\Sigma I\gamma$= 0.01%			
• ^{236}Np EC Decay (22.5 h 4)		I (min) = 0.10%	
%EC Decay = 52 1			
Feeds ^{236}U			
See also ^{236}Np β^- Decay (22.5 h)			
Auger-L	9.89	20 3	0.0042
ce-L- 1	23.485 6	5.4 3	0.0027
ce-MNO- 1	39.694 6	1.96 12	0.0017
Auger-K	72.6	0.9 7	0.0013
ce-K- 4	526.72 10	0.155 16	0.0017
X-ray L	13.6	26 3	0.0074
X-ray $K\alpha_2$	94.6650 20	11.26 24	0.0227
X-ray $K\alpha_1$	98.4390 20	18.2 4	0.0382
X-ray Kβ	111	8.50 20	0.0201
γ 4	642.33 10	1.38 8	0.0189
γ 5	687.52 10	0.367 21	0.0054
3 weak γ's omitted:			
$\Sigma E\gamma$(avg)= 304.6; $\Sigma I\gamma$= 0.03%			
• ^{236}Np β^- Decay (22.5 h 4)		I (min) = 0.10%	
%β^- Decay = 48 1			
Feeds ^{236}Pu			
See also ^{236}Np EC Decay (22.5 h)			
Auger-L	10.3	2.4 4	0.0005
ce-L- 1	21.50 10	6.06 23	0.0028
ce-MNO- 1	38.67 10	2.24 8	0.0018

(Continued)

ATTACHMENT 3

APPENDIX B

TABLE IV

UNIRRADIATED N REACTOR FUEL ELEMENT
DIMENSIONS AND ISOTOPIC COMPOSITION

	MK IA	MK IV
Outer Tube		
Zirconium Clad OD in. (cm)	2.404 (6.106)	2.425 (6.160)
Uranium OD in. (cm)	2.354 (5.979)	2.375 (6.032)
Uranium ID in. (cm)	1.817 (4.615)	1.741 (4.422)
Zirconium Clad ID in. (cm)	1.767 (4.488)	1.701 (4.320)
Clad Fuel Length in. (cm)	20.88 (53.04)	26.10 (66.29)
Uranium Core Length in. (cm)	20.51 (52.10)	25.73 (65.35)
Weight of Element U lb (kg)	24.45 (11.09)	34.88 (15.82)
Uranium Composition w/o U-235	1.25	0.947
w/o U-238	98.70	99.00
w/o U-234	0.01	0.01
W/o U-236	0.04	0.04
Inner Tube		
Zirconium Clad OD in. (cm)	1.246 (3.165)	1.279 (3.249)
Uranium OD in. (cm)	1 166 (2.962)	1.219 (3.096)
Uranium ID in. (cm)	0.490 (1.245)	0.520 (1.321)
Zirconium Clad ID in. (cm)	0.440 (1.118)	0.480 (1.219)
Clad Fuel Length in. (cm)	20.82 (52.88)	26.04 (66.14)
Uranium Core Length in. (cm)	20.45 (51.94)	25.67 (65.20)
Weight of Element U lb (kg)	12.21 (5.538)	16.30 (7.394)
Uranium Composition w/o U-235	0.947	0.947
w/o U-238	99.00	99.00
w/o U-234	0.01	0.01
w/o U-236	0.04	0.04
Assembly Weight U lb (kg)	36.7 (16.6)	51.2 (23.2)

Density Uranium 18.9 g/cc

Density Zirconium 6.4 g/cc

APPENDIX B

SUPPORTING CALCULATIONS

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RADIOLOGICAL CALCULATIONS

Volume of crib

50 ft x 60 ft x 30 ft = 9 x 10^4 ft^3

15.24 m x 18.29 m x 9.14 m = 2.55 x 10^3 m^3

Volume of dump truck

8 ft x 12 ft x 3 ft = 288 ft^3

2.44 m x 3.66 m x 0.91 m = 8.13 m3

Ratio of dump truck volume to volume of crib

$$\frac{8.13\ m^3}{2.55 \times 10^3 m^3} = 3.19 \times 10^{-3}$$

Sample dose adjustment

(3.19×10^{-3}) x (2811 mR/h) = 8.97 mR/h contact on side of dump truck. (2811 mR/h is the dose rate for the total crib inventory in one truck load).

WIND DISPERSION MODEL

This model conservatively assumes that the dispersable inventory of the crib would be spread over an area of 9 m^2 with a depth of 1 cm. This assumption would subject a portion of the inventory to resuspension by wind erosion.

Where

Concentration of ^{60}Co dust at 100 m = 2.2 x 10^{-12} mg/m^3

(2.2 x 10^{-12} mg/m^3) x (1.13 x 10^6 uCi/mg) = 2.49 x 10^{-6} uCi/m^3

Derived air concentration (DAC) ^{60}Co = 1.0 x 10^{-8} uCi/ml or 1.0 x 10^{-2} uCi/m^3

Derived concentration guide (DCG) ^{60}Co = 8.0 x 10^{-11} uCi/ml or 8.0 x 10^{-5} uCi/m^3

^{60} Co concentration at 100 m = $\frac{2.49 \times 10^{-6}\ uCi/m^3}{1.0 \times 10^{-2} uCi/m^3}$ = 2.49 x 10^{-4} $DACs/m^3$

Where the respiration rate is 1.2 m^3/h and the intake rate is

(1.2 m^3/h) x (2.49 x 10^{-4} $DACs/m^3$) = 2.99 x 10^{-4} DACs/h

8,760 h x 1 DCG = 0.1 rem effective dose equivalent (EDE)

2,000 h x 1 DAC/h = 5 rem EDE

At 0.1 DAC, respiratory protection is required.

Therefore, at 100 m and using the most conservative model available, the air concentration for the most limiting isotope within the crib would not reach a level requiring public concern (DCG). Consequently, the exposure to the receptor groups would be well below the risk acceptance limits in WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*.

Because the model is not reliable for concentrations at less than 100 m, a conservative estimate for dust loading is multiplied by contaminant concentration per gram of soil by dust loading per unit volume of air. A conservative estimate of the airborne potential to the facility worker can be made.

Dust loading = 10 mg/m^3 in air

^{60}Co 3.7 x 10^4 pCi/g in soil

(1.0 x 10^{-2} g/m^3) x (3.7 x 10^{-2} uCi/g) = 3.7 x 10^{-4} uCi/m^3 or 3.7 x 10^{-10} uCi/cm^3

CHEMICAL CALCULATIONS

Calculations for release of chemical contaminants are based upon a source term for 9 m^2, the surface area of soil in the dump truck and a depth of 1 cm. This is the volume of soil subject to resuspension.

Where

97 ft^2 = the area of the dump truck.

In the following calculations we use the dimensions of a circle.

1/4 pi D^2 = area

97 = 1/4 pi D^2

11.11 ft = diameter

1/2 D = radius

5.56 ft (1.69 m) (parameter for model input) = radius

14.9 mi/h (or 6.7 m/s) (parameter for model input) = wind velocity.

A minimum of 13 mi/h is required to resuspend dust; below 13 mi/h, resuspension is not possible. At 15 mi/h, regulations require activities at the Hanford Site be suspended because of the possibility of contamination being spread by wind.

Conversion of the top centimeter of soil to grams

$$97\ ft^2 \times 0.0328\ ft = 3.2\ ft^3 = 9.1\ E^4\ cm^3$$

Conversion of volume to weight

$$(9.1\ E^4\ cm^3) \times (2\ g/cm^3) = 1.82\ E^5\ g \text{ of soil subject to resuspension.}$$

Release rate example (Ag)

$$(1.82\ E^5\ g \text{ of soil}) \times (362\ ug\ Ag/g \text{ of soil}) \times (3.5\ E^{-6}/s \text{ release rate fraction}) = 2.3\ E^{-4}\ g/s\ Ag \text{ (parameter for model input)}$$

Where

6.7 m/s = wind speed (parameter)

1.69 m (parameter) = radius

$3.5\ E^{-6}/s$ = release rate fraction

$(2.5\ E^{-4}\ g/s)$ Ag (parameter).

Table B-1 provides a summation of models by contaminants.

Table B-1. Summation of Model by Contaminant (mg/m^3).

Distance in meters	Silver	Chromium	Copper	Nickel	Uranium	Arrival time in minutes
5,000	$2.7\ 10^{-7}$	$4.6\ 10^{-7}$	$7.0\ 10^{-5}$	$1.3\ 10^{-6}$	$7.1\ 10^{-6}$	12
4,000	$3.8\ 10^{-7}$	$6.3\ 10^{-7}$	$9.8\ 10^{-5}$	$1.8\ 10^{-6}$	$9.8\ 10^{-6}$	10
3,000	$5.8\ 10^{-7}$	$9.7\ 10^{-7}$	$1.5\ 10^{-4}$	$2.8\ 10^{-6}$	$1.5\ 10^{-5}$	7
2,000	$1.1\ 10^{-6}$	$1.8\ 10^{-6}$	$2.8\ 10^{-4}$	$5.3\ 10^{-6}$	$2.8\ 10^{-5}$	5
1,000	$3.3\ 10^{-6}$	$5.6\ 10^{-6}$	$8.6\ 10^{-4}$	$1.6\ 10^{-5}$	$8.7\ 10^{-5}$	2
900	$4.0\ 10^{-6}$	$6.6\ 10^{-6}$	$1.0\ 10^{-3}$	$1.9\ 10^{-5}$	$1.0\ 10^{-4}$	2
800	$4.8\ 10^{-6}$	$8.1\ 10^{-6}$	$1.3\ 10^{-3}$	$2.4\ 10^{-5}$	$1.3\ 10^{-4}$	2
700	$6.1\ 10^{-6}$	$1.0\ 10^{-5}$	$1.6\ 10^{-3}$	$3.0\ 10^{-5}$	$1.6\ 10^{-4}$	2
600	$7.9\ 10^{-6}$	$1.3\ 10^{-5}$	$2.0\ 10^{-3}$ *	$3.9\ 10^{-5}$	$2.1\ 10^{-4}$	1
500	$1.1\ 10^{-5}$	$1.8\ 10^{-5}$	$2.8\ 10^{-3}$	$5.3\ 10^{-5}$	$2.8\ 10^{-4}$	1
400	$1.6\ 10^{-5}$	$2.7\ 10^{-5}$	$4.2\ 10^{-3}$	$7.8\ 10^{-5}$	$4.2\ 10^{-4}$	1
300	$2.7\ 10^{-5}$	$4.5\ 10^{-5}$	$6.9\ 10^{-3}$	$1.3\ 10^{-4}$	$7.0\ 10^{-4}$	1
200	$5.5\ 10^{-5}$	$9.3\ 10^{-5}$	$1.4\ 10^{-2}$	$2.7\ 10^{-4}$	$1.4\ 10^{-3}$	0
100	$1.9\ 10^{-4}$	$3.2\ 10^{-4}$	$4.9\ 10^{-2}$	$9.3\ 10^{-4}$	$4.9\ 10^{-3}$	0

CALCULATIONS FOR WATER TREATMENT

In the 300 Area, approximately 1.51×10^5 L (40,000 gal) of washwater is currently stored in "fract" tanks. Approximately 5% of that quantity will be precipitated out via a water treatment system (7.55×10^3 L). The water treatment system is described in Appendix D.

$(1.51 \times 10^5 \text{ L}) \times 0.05 = 7.55 \times 10^3 \text{ L}$ of solids

The effluent will be pumped into BF-25 boxes for disposal.

The dimensions of BF-25 boxes are as follows:

$(1.22 \text{ m}) \times (1.5 \text{ m}) \times (1.83 \text{ m}) = 3.39 \text{ m}^3$

$3.39 \text{ m}^3 = 3.39 \times 10^3$ L/ BF-25 burial box

$4 \times (3.39 \times 10^3 \text{ L}) = 1.36 \times 10^4$ L (total volume of four BF-25 boxes)

CONCENTRATION OF CONTAMINANTS IN WATER

Average concentration of uranium concentration in seven water samples was 40 mg/L; the range of samples was 10,200 to 93,700 ug/L.

$(4.0 \times 10^{-5} \text{ kg/L}) \times (1.51 \times 10^5 \text{ L of water}) = 6.04$ kg (13.32 lb) of uranium in the stored water.

Expected removal of contaminants is at 95% efficiency; therefore

$0.95 \times 6.04 \text{ kg} = 5.74$ kg (12.65 lb) of uranium in the burial boxes.

5.74 kg divided by 4 boxes = 1.44 kg of uranium per burial box.

Using the above method, and anticipating equivalent extraction, expected weights of other contaminants follow.

Silver	avg = 0.53 mg/L	= 0.076 kg total removed	= 0.019 kg/box
Chromium	avg = 5.77 mg/L	= 0.83 kg total removed	= 0.21 kg/box
Copper	avg = 44.5 mg/L	= 6.38 kg total removed	= 1.6 kg/box
Nickel	avg = 4.99 mg/L	= 0.75 kg total removed	= 0.19 kg/box

The system is set up to reprocess water that does not extract all contaminants; therefore, water will continuously be processed through the system to as low as reasonably achievable.

EXAMPLE CALCULATION FOR RESIDUAL CONTAMINANTS IN PROCESSED WATER

Where

0.53 mg/L = average concentration of silver in water used in soil washing.

(0.53 mg/L of silver) x (1.51×10^5 L of water) = 8.00×10^1 g Ag total.

If 95% of silver is removed, 0.4 g of silver will remain in the treated water. Also, $7.55\ 10^3$ L of solids were removed. Therefore, 1.51×10^5 L minus 7.55×10^3 L $= 1.43 \times 10^5$ L of water remaining.

$$\frac{0.4 \text{ g silver}}{1.43 \times 10^5 \text{ L}} = 2.8 \times 10^{-6} \text{g/L} \quad \text{or} \quad 2.8 \times 10^{-3} \text{ mg/L of silver in water}$$

Table B-2. Residual Contaminants in Processed Water.

Remaining contaminants in treated water	Concentration in mg/L	Standards for groundwater*
Silver	2.8×10^{-3} mg/L	0.05 mg/L
Chromium	3.05×10^{-1} mg/L	0.05 mg/L
Copper	1.78 mg/L	1.0 mg/L
Nickel	2.63×10^{-1} mg/L	--
Uranium	4.56 x 10 nCi/L	15 pCi/L

*Source: WHC-CM-7-5, *Environmental Compliance*, Westinghouse Hanford Company, Richland, Washington.

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EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : COBALT 60 Library-

ERPG-1 : 335610718480000000000000000000000000 ppm ERPG-2 : 3074059592900000000

AREA, CONTINUOUS : 2.7E-12 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > < 0.0001 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	2.2E-12	0: 0
0.20	6.4E-13	0: 0
0.30	3.1E-13	0: 1
0.40	1.9E-13	0: 1
0.50	1.3E-13	0: 1
0.60	9.1E-14	0: 1
0.70	7.0E-14	0: 2
0.80	5.6E-14	0: 2
0.90	4.6E-14	0: 2
1.00	3.8E-14	0: 2
2.00	1.2E-14	0: 5
3.00	6.7E-15	0: 7
4.00	4.3E-15	0:10
5.00	3.1E-15	0:12
6.00	2.4E-15	0:15
7.00	1.9E-15	0:17
8.00	1.6E-15	0:20
9.00	1.4E-15	0:22
10.0	1.2E-15	0:25
20.0	4.7E-16	0:50
40.0	2.0E-16	1:40
60.0	1.2E-16	2:29
80.0	8.3E-17	3:19
100	6.4E-17	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : URANIUM Library-XY
Molecular Weight : 238.0 gram/mole
CAS Number: [7440-61-1]
TWA : 0.20 mg/m^3
STEL : 0.60 mg/m^3
IDLH : 20 mg/m^3

AREA, CONTINUOUS : 6.0E-03 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 4.9E-03 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	0.0049	0: 0
0.20	0.0014	0: 0
0.30	7.0E-04	0: 1
0.40	4.2E-04	0: 1
0.50	2.8E-04	0: 1
0.60	2.1E-04	0: 1
0.70	1.6E-04	0: 2
0.80	1.3E-04	0: 2
0.90	1.0E-04	0: 2
1.00	8.7E-05	0: 2
2.00	2.8E-05	0: 5
3.00	1.5E-05	0: 7
4.00	9.8E-06	0:10
5.00	7.1E-06	0:12
6.00	5.4E-06	0:15
7.00	4.4E-06	0:17
8.00	3.6E-06	0:20
9.00	3.1E-06	0:22
10.0	2.7E-06	0:25
20.0	1.1E-06	0:50
40.0	4.4E-07	1:40
60.0	2.7E-07	2:29
80.0	1.9E-07	3:19
100	1.4E-07	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : NICKEL Library-91
Molecular Weight : 58.7 gram/mole
CAS Number: [7440-02-0]
TWA : 0.100 mg/m^3

AREA, CONTINUOUS : 1.1E-03 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED : 6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 9.3E-04 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	9.3E-04	0: 0
0.20	2.7E-04	0: 0
0.30	1.3E-04	0: 1
0.40	7.8E-05	0: 1
0.50	5.3E-05	0: 1
0.60	3.9E-05	0: 1
0.70	3.0E-05	0: 2
0.80	2.4E-05	0: 2
0.90	1.9E-05	0: 2
1.00	1.6E-05	0: 2
2.00	5.3E-06	0: 5
3.00	2.8E-06	0: 7
4.00	1.8E-06	0:10
5.00	1.3E-06	0:12
6.00	1.0E-06	0:15
7.00	8.2E-07	0:17
8.00	6.8E-07	0:20
9.00	5.8E-07	0:22
10.0	5.1E-07	0:25
20.0	2.0E-07	0:50
40.0	8.3E-08	1:40
60.0	5.0E-08	2:29
80.0	3.5E-08	3:19
100	2.7E-08	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : COPPER Library-91
Molecular Weight : 63.5 gram/mole
CAS Number: [7440-50-8]
TWA : 0.20 mg/m^3

AREA, CONTINUOUS : 6.0E-02 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 4.9E-02 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	0.049	0: 0
0.20	0.014	0: 0
0.30	0.0069	0: 1
0.40	0.0042	0: 1
0.50	0.0028	0: 1
0.60	0.0020	0: 1
0.70	0.0016	0: 2
0.80	0.0013	0: 2
0.90	0.0010	0: 2
1.00	8.6E-04	0: 2
2.00	2.8E-04	0: 5
3.00	1.5E-04	0: 7
4.00	9.8E-05	0:10
5.00	7.0E-05	0:12
6.00	5.4E-05	0:15
7.00	4.4E-05	0:17
8.00	3.6E-05	0:20
9.00	3.1E-05	0:22
10.0	2.7E-05	0:25
20.0	1.1E-05	0:50
40.0	4.4E-06	1:40
60.0	2.7E-06	2:29
80.0	1.9E-06	3:19
100	1.4E-06	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : CHROMIUM Library-91
Molecular Weight : 52.0 gram/mole
CAS Number: [7440-47-3]
TWA : 0.50 mg/m^3
IDLH : 500 mg/m^3

AREA, CONTINUOUS : 3.8E-04 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 3.2E-04 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	3.2E-04	0: 0
0.20	9.3E-05	0: 0
0.30	4.5E-05	0: 1
0.40	2.7E-05	0: 1
0.50	1.8E-05	0: 1
0.60	1.3E-05	0: 1
0.70	1.0E-05	0: 2
0.80	8.1E-06	0: 2
0.90	6.6E-06	0: 2
1.00	5.6E-06	0: 2
2.00	1.8E-06	0: 5
3.00	9.7E-07	0: 7
4.00	6.3E-07	0:10
5.00	4.6E-07	0:12
6.00	3.5E-07	0:15
7.00	2.8E-07	0:17
8.00	2.4E-07	0:20
9.00	2.0E-07	0:22
10.0	1.7E-07	0:25
20.0	6.9E-08	0:50
40.0	2.9E-08	1:40
60.0	1.7E-08	2:29
80.0	1.2E-08	3:19
100	9.2E-09	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : SILVER Library-91
Molecular Weight : 107.9 gram/mole
CAS Number: [7440-22-4]
TWA : 0.0100 mg/m^3

AREA, CONTINUOUS : 2.3E-04 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters

LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 1.9E-04 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	1.9E-04	0: 0
0.20	5.5E-05	0: 0
0.30	2.7E-05	0: 1
0.40	1.6E-05	0: 1
0.50	1.1E-05	0: 1
0.60	7.9E-06	0: 1
0.70	6.1E-06	0: 2
0.80	4.8E-06	0: 2
0.90	4.0E-06	0: 2
1.00	3.3E-06	0: 2
2.00	1.1E-06	0: 5
3.00	5.8E-07	0: 7
4.00	3.8E-07	0:10
5.00	2.7E-07	0:12
6.00	2.1E-07	0:15
7.00	1.7E-07	0:17
8.00	1.4E-07	0:20
9.00	1.2E-07	0:22
10.0	1.0E-07	0:25
20.0	4.1E-08	0:50
40.0	1.7E-08	1:40
60.0	1.0E-08	2:29
80.0	7.2E-09	3:19
100	5.5E-09	4: 9

APPENDIX C

MODIFIED ENVIRONMENTAL PROTECTION AGENCY SOILS WASHING SYSTEM

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The oversize (2- to 0.425-mm or 0.210-mm) material from the secondary screen will exit the system as clean material. The undersize (-0.425- or -0.210-mm) material will leave the screen as a slurry. This slurry will be stored in fractionation (frac) tanks and treated after the test is completed. The anticipated treatment will consist of filtering the fines out and containing them in low specific activity boxes and then transporting the water to the purge water tanks for evaporation. More detail about the low specific activity containers is given in Attachment A, Chapter 4, Water Treatment And Residual Handling.

An operating and maintenance manual for the trommel trailer will provide the required procedures for setup, startup, operation, shutdown, teardown, and maintenance. This manual came with the equipment when transferred to DOE, Richland Operations (RL) from the EPA Risk Reduction Engineering Laboratory.

The system will be set up initially using some baseline operating parameters. These parameters may be altered during operation and the changes will be detailed in the final report. The baseline operating parameters are as follows:

Primary Screen:	
Area	0.75 by 2.4 m (2.5 by 8 ft)
Size	25.4 mm (1.0 in.)
Slope	0.0 deg
Soil Flowrate	8.2 dmt/hr (9.0 dst/hr)
Nozzle Pressure	2.8 kg/cm^2 (40 lb/in^2)
Nozzle Flowrate (total)	38 L/min (10 gal/min)
Underflow percent solids	1.2% solids by weight
Trommel:	
Size	1.37-m dia. by 6.4 m (4.5 by 21 ft)
Speed	2.9 rpm
Angle	3.0 deg
Screen Size	2.0 mm (0.08 in.)
Soil Flowrate	3.6 mt/hr (4.0 st/hr)
Underflow Percent Solids	10.2% solids by weight
Retention Time	21 min.
Initial Rinse: (15)	
Pressure	4.2 kg/cm^2 (60 lb/in^2)
Flowrate (total)	600 L/min (160 gal/min)
Final Rinse: (9)	
Pressure	2.8 kg/cm^2 (40 lb/in^2)
Flowrate (total)	265 L/min (70 gal/min)
Secondary Screen:	
Area	0.56 by 2.1 m (1.8 by 7 ft)
Size-Test #1	0.425 mm (0.02 in.)
Size-Test #1	0.210 mm (0.01 in.)
Slope	0.0 deg
Soil Flowrate	2.1 mt/hr (2.3 st/hr)
Underflow Percent Solids	
-Test #1	2.8% solids by weight
-Test #2	1.4% solids by weight

Figure C-1. Environmental Protection Agency Modified Soil Washing System.

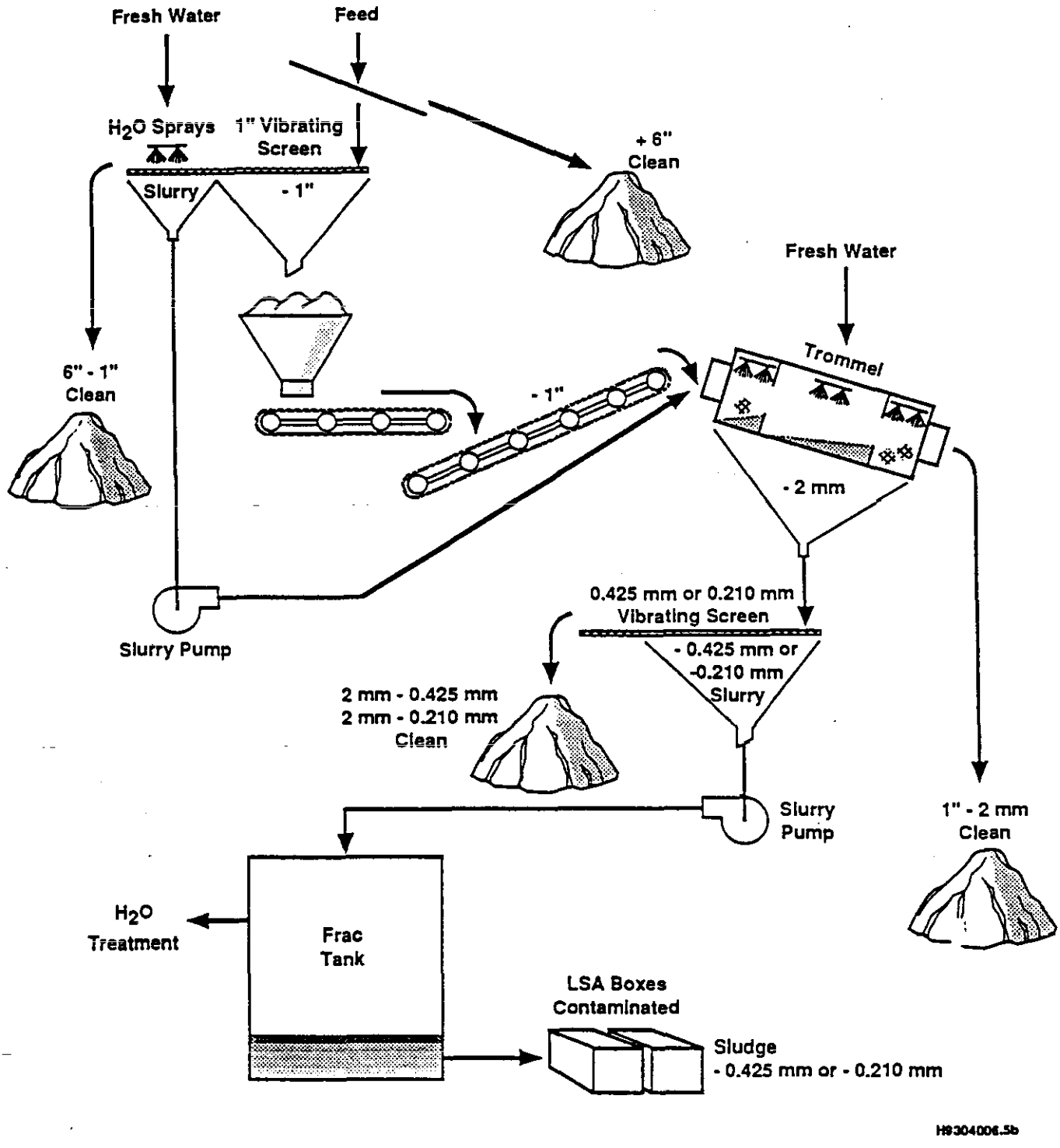
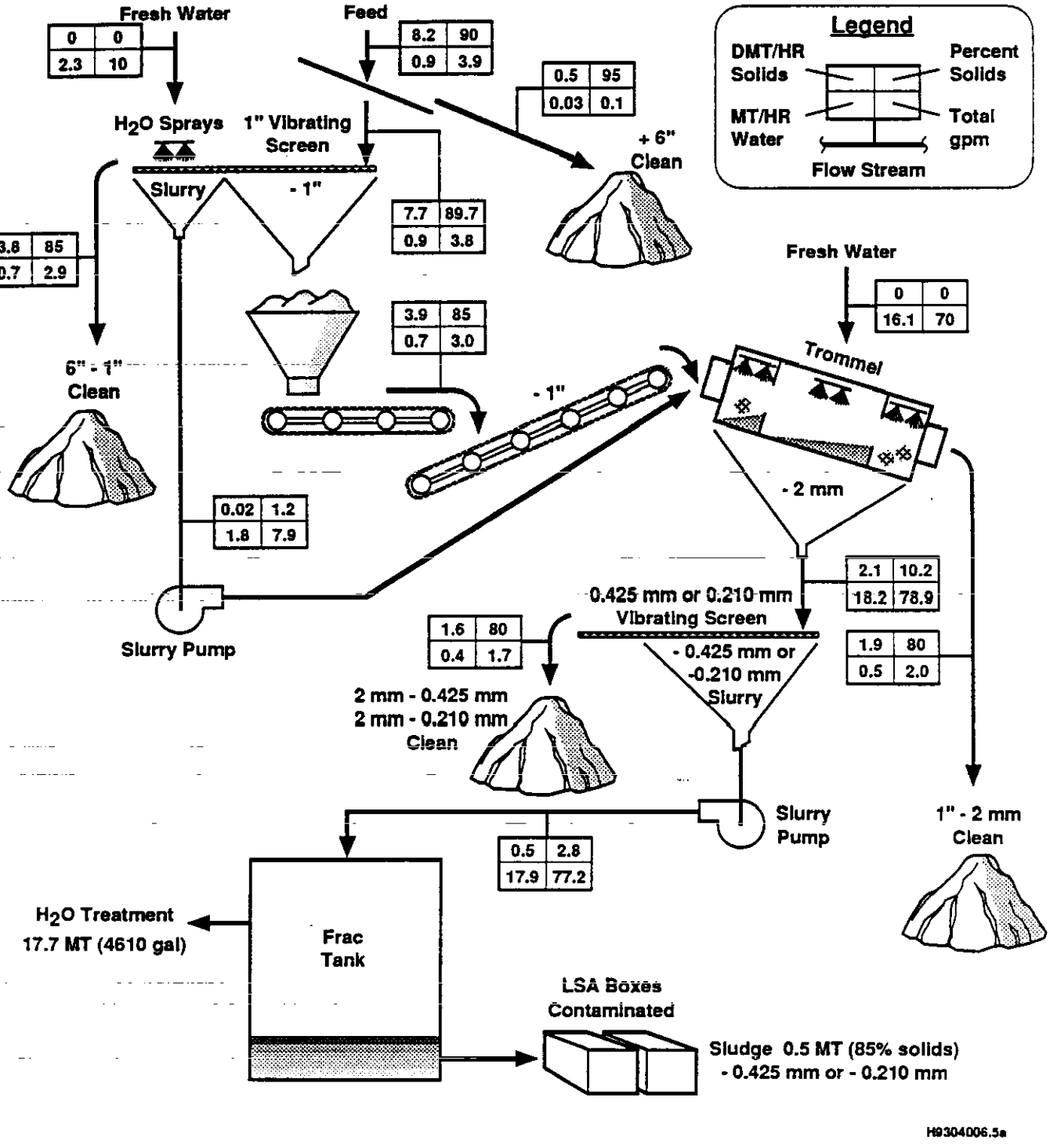


Figure C-2. Modified Environmental Protection Agency Soil Washing System - Baseline Material Balance (per Hour of Operation).



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APPENDIX D

WATER TREATMENT SYSTEM

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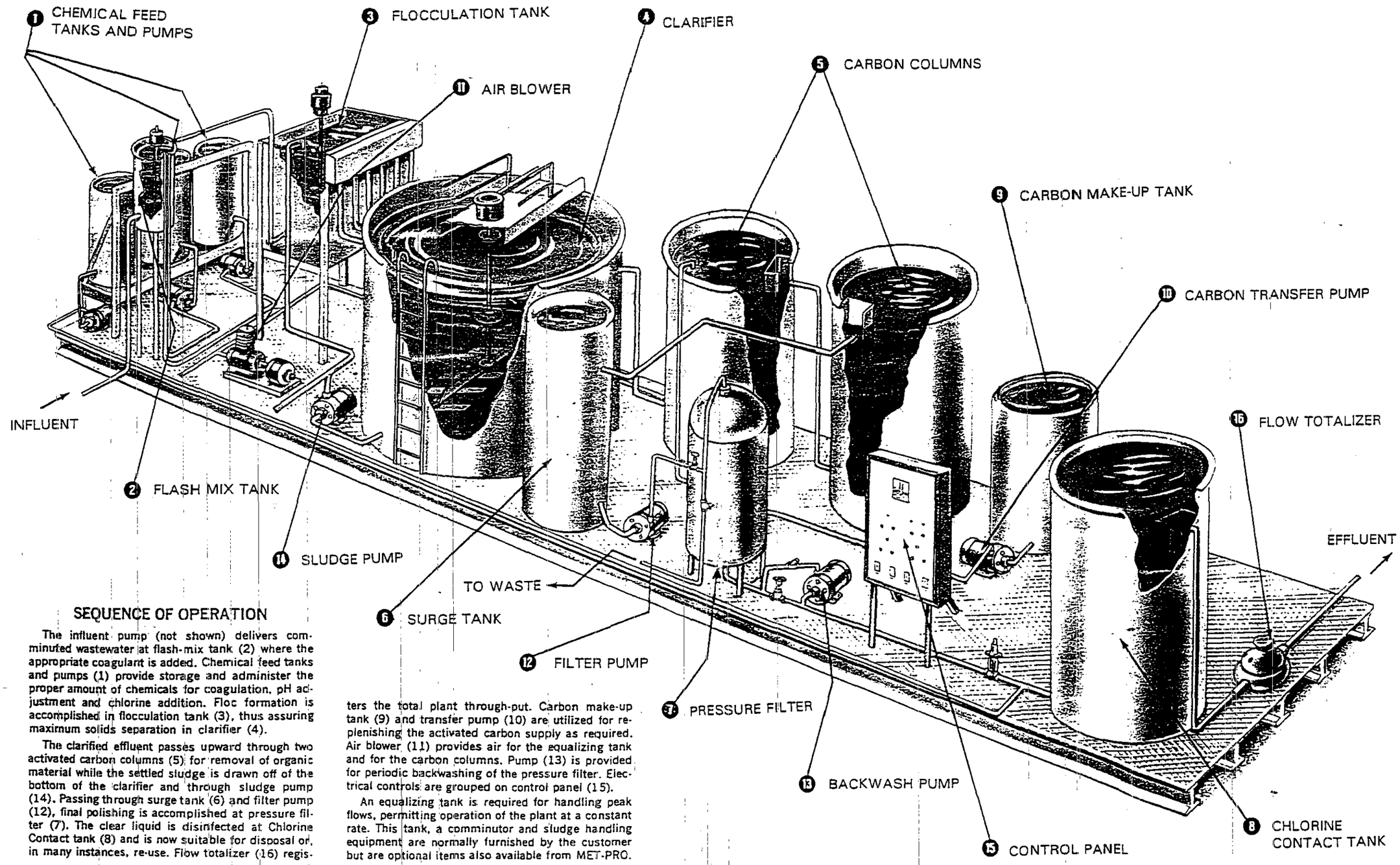

SEQUENCE OF OPERATION

The influent pump (not shown) delivers comminuted wastewater at flash-mix tank (2) where the appropriate coagulant is added. Chemical feed tanks and pumps (1) provide storage and administer the proper amount of chemicals for coagulation, pH adjustment and chlorine addition. Floc formation is accomplished in flocculation tank (3), thus assuring maximum solids separation in clarifier (4).

The clarified effluent passes upward through two activated carbon columns (5) for removal of organic material while the settled sludge is drawn off of the bottom of the clarifier and through sludge pump (14). Passing through surge tank (6) and filter pump (12), final polishing is accomplished at pressure filter (7). The clear liquid is disinfected at Chlorine Contact tank (8) and is now suitable for disposal or, in many instances, re-use. Flow totalizer (16) registers the total plant through-put. Carbon make-up tank (9) and transfer pump (10) are utilized for replenishing the activated carbon supply as required. Air blower (11) provides air for the equalizing tank and for the carbon columns. Pump (13) is provided for periodic backwashing of the pressure filter. Electrical controls are grouped on control panel (15).

An equalizing tank is required for handling peak flows, permitting operation of the plant at a constant rate. This tank, a comminutor and sludge handling equipment are normally furnished by the customer but are optional items also available from MET-PRO.

Note: Illustrations and text refer to the Series 12000 IPC Systems. Other designs also available from MET-PRO.

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TANKAGE

Title	Dimensions (Diameter) Inches	Dimensions (Height) Inches	Full Volume (Gal.)	Residence Time (Min.)
Flash Mix	20	48	65	1.86
Flocculation	48x48 Sq.	57	570	16.2
Clarifier	120	96	4,710	135
Acid Mix	22	36	75	2.16
Upflow Adsorber	48	96	756 @ 35 gpm =	21.6
Downflow Adsorber	48	96	756	21.6
Pressure Filter	36	60	(1)	(1)
Surge	36	96	424	12
Chlorine Contact	60	96	1,178	33.6
Chemical Feed	24	48	94	(2)
Lime Slurry	48	48	360	(2)

Note: This is not the operating volume, so residence times shown will be lower.

(1) 4.95 GPM/square foot surface.
(2) Usually 1-1/2 days storage.

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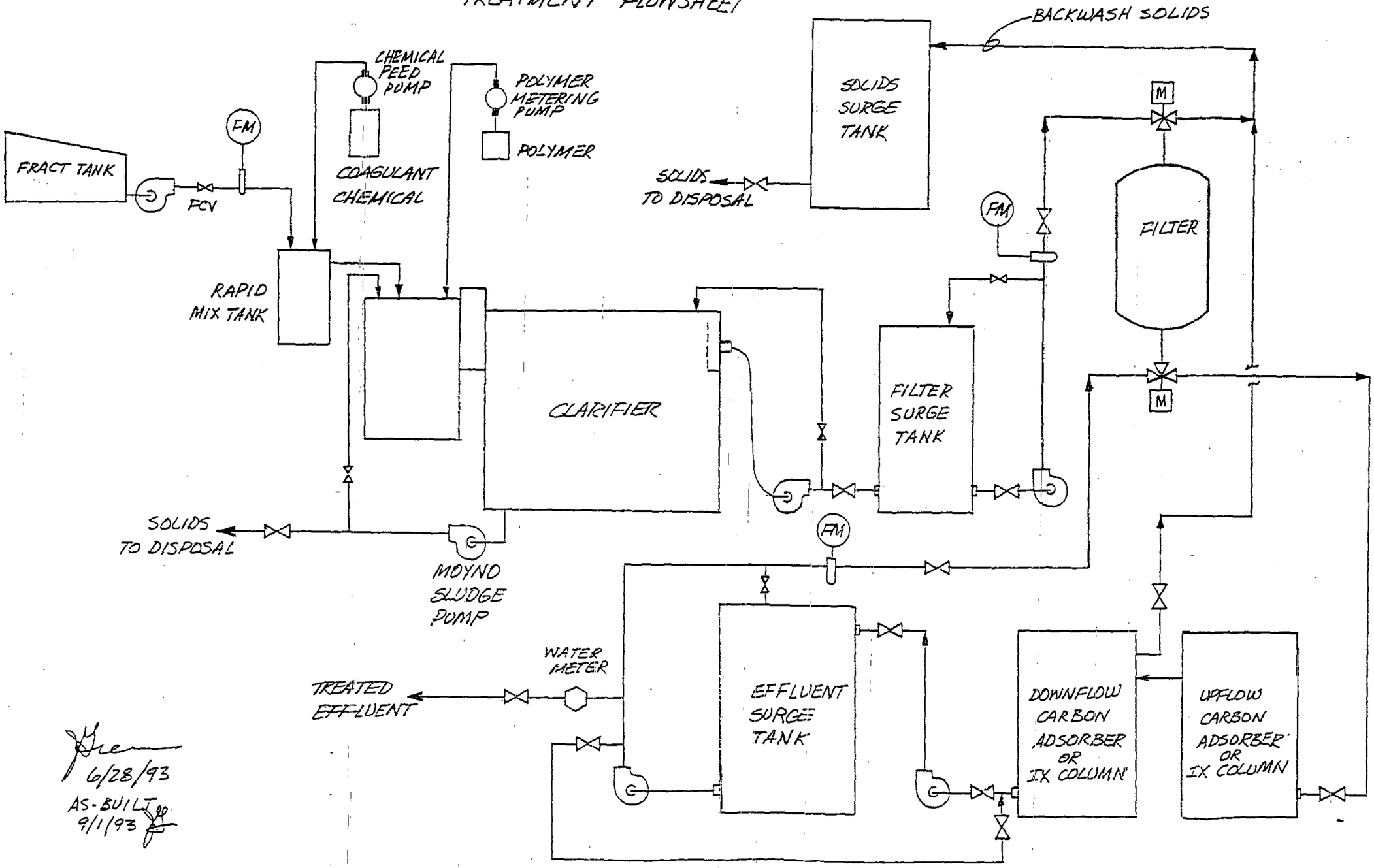
MET-PRO PHYS-CHEM TREATMENT FLOWSHEET



6/28/93
AS-BUILT
9/1/93

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300 AREA SOIL WASHING RESULTS

	MINUS 0.425mm SLURRY WATER (UNFILTERED) JUNE 1993 PROCESSING							MINUS 0.425mm SLURRY SOILS JUNE 1993 PROCESSING						
	B07C75 water mg/L	B07C76 water mg/L	B07C77 water mg/L	B07C85 water mg/L	B07C79 water mg/L	B07C80 water mg/L	B07C81 water mg/L	B07C91 soil mg/kg	B07C92 soil mg/kg	B07C93 soil mg/kg	B07C95 soil mg/kg	B07C96 soil mg/kg	B07C97 soil mg/kg	B07CB1 soil mg/kg
Ag	0.05	1	0.53	0.98	0.64	0.3	0.16	2.1	1.5 L	1.1 L	2.2	1.5 L	2.8	1.9 L
Al	37	850	550	770	1000	480	250	7600	7800	7100	8900	10000	9900	6900
As	0.003 L	0.024	0.028	0.026	0.023	0.022	0.011	1.3	1.2	1.2	2.2	1.1	1.7	1
Ba	2.1	67	43	60	120	59	27	220	200	190	310	380	390	300
Be	0.0013 L	0.018	0.011	0.018	0.018	0.0082	0.0042	0.24 L	0.23 L	0.18 L	0.1 L	0.22 L	0.2 L	0.21 L
Ca	19	400	170	400	850	170	100	9900	4000	3800	5100	5000	5400	4100
Cd	0 U	0.011	0 U	0.0091 L	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Co	0.0071 L	0.095	0.14	0.092	0.27	0.13	0.066	3.6	4.6	4.9	6	4.7	5.3	5
Cr	0.38	9.2	5.5	8.6	9.5	4.6	2.6	34	30	28	45	44	53	40
Cu	3.5	100	50	98	60	29	25	320	240	150	420	420	500	260
Fe	13	230	160	220	270	130	63	12000	13000	15000	19000	14000	15000	14000
Hg	0.0045	0.13	0.078	0.14	0.12	0.096	0.049	0.3 L	0.2 L	0.35 L	0.49	0.3 L	0.48	0.54
K	3.5	34	24	33	37	18	9.2	670	750	730	800	810	790	650
Mg	10	190	120	170	210	100	59	3100	3100	3300	3800	3700	3700	3200
Mn	0.27	5.3	3.7	4.9	6	2.9	1.6	160	180	200	220	180	180	170
Na	31	120	110	120	170	96	66	640	650	650	710	890	900	620
Ni	0.32	10	6	9.6	5.3	2.7	2	34	27	22	40	30	47	29
Pb	0.093	2.6	1.1	2.1	2.1	0.98	0.55	13	13	11	18	15	24	17
Sb	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	4.4 L	0 U	0 U	4.5 L	0 U
Sn	0.061 L	1	0.68	0.89	1.3	0.67	0.38	0 U	6 L	0 U	0 U	6.1 L	0 U	0 U
V	0.0089 L	0.36	0.22	0.36	0.4	0.19	0.097	37	38	48	61	42	45	39
Zn	0.11	2.6	1.7	2.4	3	1.5	0.89	35	36	37	44	42	44	39

	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Co-60	-2.58	2.19	11.9	0.877	-3.78	16.6	-3.72	-0.000	-0.013	-0.008	-0.006	0.0090	0.0073	0.0077
Cs-137	1.32	0.0867	9.56	5.47	4.86	7.43	25.1	0.152	0.118	0.138	0.174	0.279	0.303	0.224
Pb-212								0.696	0.604	0.834	0.828	0.724	0.821	0.917
Pb-214								0.511	0.403	0.556	0.424	0.518	0.478	0.619
Ra-224								0.608	0.616	0.85	0.84	0.734	0.832	0.55
Ra-226								0.461	0.459	0.534	0.448	0.458	0.509	0.929
Ru-106	23.3	47.9	-67	-20.6	-75.7	80.8	-28.4	0.0369	0.209	0.0928	0.0307	-0.142	0.446	0.0867
Sb-125	-12.2	-3.67	42.3	-2.11	27.7	-38.7	30.2	0.0251	0.0062	0.0726	0.0429	0.0428	-0.070	-0.073

	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
U-Nat	10200	24800	58000	30600	93700	38500	23400	217	214	158	173	358	355	827

MATERIAL SAFETY DATA SHEET

Calgon Corporation
P.O. Box 1346
Pittsburgh, PA 15230-1346

24 Hour Emergency Telephone—(412)777-8000

CALGON CORPORATION
SUBSIDIARY OF MERCK & CO., INC.

Section 1. PRODUCT IDENTIFICATION

PRODUCT NAME: Cat-Floc L

CHEMICAL DESCRIPTION: Aqueous solution of cationic polymer
PRODUCT CLASS: Water treatment
MSDS CODE: 0170-10-22-91

Section 2. HAZARDOUS INGREDIENTS AND EXPOSURE LIMITS

Chemical Name	CAS Number	% by Weight	OSHA PEL	ACGIH TLV

"No ingredients listed in this section"

HAZARD COMMUNICATION STATUS: This product is not considered to be hazardous according to the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200.

Section 3. HAZARDS IDENTIFICATION

********** EMERGENCY OVERVIEW **********

This product poses little or no immediate hazard.

****

PRIMARY ROUTES OF ENTRY: None

TARGET ORGANS: None

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Unknown

MATERIAL SAFETY DATA SHEET

POTENTIAL HEALTH EFFECTS:

EYE CONTACT: This product would not be expected to produce irritation upon contact with the eye.

SKIN CONTACT: The product is not expected to cause skin irritation upon contact. Data indicate that this product will not produce an allergic skin reaction or be absorbed through the skin in harmful amounts.

INGESTION: This product would be expected to be practically non-toxic by ingestion.

INHALATION: This product is not expected to present an inhalation hazard.

SUBCHRONIC, CHRONIC:
In a subchronic toxicity study using rats, the active ingredient of this product was administered orally at doses of 5, 50, and 500 mg/kg. Animals in the 50 mg/kg group showed decreased weight gain, decreased food consumption and increased sleeping time. Animals in the 500 mg/kg group showed decreased weight gain, decreased food consumption, and alterations in red blood cells and blood proteins. Animals in the 5 mg/kg group showed no effects. Twelve-month feeding studies using rats and dogs given 2 and 200 ppm active ingredient in drinking water showed no significant adverse effects.

A similar product has been shown not to be mutagenic by the Ames assay. A teratology study in rabbits and a two-generation reproduction study in rats showed this product did not produce birth defects or affect reproduction.

CARCINOGENICITY:
NTP:
"No ingredients listed in this section"
IARC:
"No ingredients listed in this section"
OSHA:
"No ingredients listed in this section"

Section 4. FIRST AID MEASURES

EYE CONTACT: Not expected to require first aid measures.

SKIN CONTACT: Not expected to require first aid measures.

INGESTION: Not an expected route of overexposure.

INHALATION: Not an expected route of overexposure.

Section 5. FIRE-FIGHTING MEASURES

FLASH POINT: > 200°F This product is not flammable or combustible.

LOWER FLAMMABLE LIMIT: Not available UPPER FLAMMABLE LIMIT: Not available

AUTO-IGNITION TEMPERATURE: Not available

MATERIAL SAFETY DATA SHEET

EXTINGUISHING MEDIA: Use extinguishing media appropriate for the surrounding fire.

FIRE-FIGHTING INSTRUCTIONS: Exercise caution when fighting any chemical fire. A self-contained breathing apparatus and protective clothing are essential.

FIRE & EXPLOSION HAZARDS: Product emits toxic gases under fire conditions.

DECOMPOSITION PRODUCTS: Carbon monoxide; carbon dioxide, hydrogen chloride, ammonia, oxides of nitrogen.

NFPA RATINGS: Health = 0 Flammability = 0 Reactivity = 0 Special Hazard = None

Hazard rating scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

Section 6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Wearing appropriate personal protective equipment, contain spill, collect onto inert absorbent and place into suitable container. Hose spill area well since product can make floors slippery.

Section 7. HANDLING AND STORAGE

HANDLING: As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the product and ensure prompt removal from eyes, skin and clothing.
Wash thoroughly after handling.
Keep container closed when not in use.

STORAGE: Product must be maintained at 38°F or higher. Protect from low temperatures.

Section 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

PERSONAL PROTECTIVE EQUIPMENT:

EYE/FACE PROTECTION: Chemical splash goggles recommended as a good industrial hygiene practice.
SKIN PROTECTION: No special requirement.
RESPIRATORY PROTECTION: None required.

ENGINEERING CONTROLS: No specific recommendations.

Section 9. PHYSICAL AND CHEMICAL PROPERTIES

BOILING POINT: > 212°F (> 100°C)	SOLUBILITY IN WATER: Complete
VAPOR PRESSURE: Similar to water	SPECIFIC GRAVITY: 1.02 - 1.04
VAPOR DENSITY (air = 1): Similar to water	pH: 6.0 - 8.0

MATERIAL SAFETY DATA SHEET

% VOLATILE BY WEIGHT: ~ 80 FREEZING POINT: Not available

APPEARANCE AND ODOR: Viscous, clear, colorless to pale yellow liquid

Section 10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable HAZARDOUS POLYMERIZATION: Will not occur

CONDITIONS TO AVOID: No specific information.

INCOMPATIBILITY: Strong acids and bases, carbon steel, copper

DECOMPOSITION PRODUCTS: Carbon monoxide, carbon dioxide, hydrogen chloride, ammonia, oxides of nitrogen.

Section 11. TOXICOLOGICAL INFORMATION

ON PRODUCT:

Oral LD50 (rat): 14.6 g/kg
Dermal LD50 (rabbit): > 20 g/kg (testing on a 40% solution of the polymer)
Eye irritation: A 40% solution of the polymer when instilled in rabbit eyes did not produce any ocular irritation during the 7-day observation period with the exception of one test eye in the no wash group at 24 hours which showed slight conjunctival effects.
Skin irritation: The primary skin irritation index (rabbits) for 40% solution of the polymer was found to be 1.0/8. Skin sensitization: Human patch testing on a higher molecular weight version of the polymer has shown that it is not a skin sensitizer.

ON INGREDIENTS:

Chemical Name	Oral LD_{50} (rat)	Dermal LD_{50} (rabbit)	Inhalation LC_{50} (rat)
No ingredients listed in this section			

Section 12. ECOLOGICAL INFORMATION

ON PRODUCT:

See information on polymer below.

ON INGREDIENTS:

Chemical Name	Aquatic Toxicity Data
Poly(dimethyldiallylammonium chloride)-40% solution	96 hr LC50 (bluegill sunfish): 0.82 - 1.3 ppm 96 hr LC50 (rainbow trout): 0.37 ppm 48 hr LC50 (Daphnia magna): 0.9 ppm (in clear water) 48 hr LC50 (Daphnia magna): 1.2 - 2.5 ppm (in 50 ppm clay suspension) 48 hr LC50 (Daphnia magna): 24.8 ppm (in 1000 ppm clay suspension) Note a substantial reduction in toxicity is observed under turbid conditions.

MATERIAL SAFETY DATA SHEET

Section 13. DISPOSAL CONSIDERATIONS

RCRA STATUS: Discarded product, as sold, would not be considered a RCRA Hazardous Waste.

DISPOSAL: Dispose of in accordance with local, state and federal regulations.

Section 14. TRANSPORT INFORMATION

DOT CLASSIFICATION:
Hazard Class: Not restricted
Proper Shipping Name: Not applicable
ID Number: Not applicable
Label: None

Section 15. REGULATORY INFORMATION

OSHA Hazard Communication Status: Nonhazardous
TSCA: The ingredients of this product are listed on the Toxic Substances Control Act (TSCA) Chemical Substances Inventory.
CERCLA reportable quantity of EPA hazardous substances in product:

Chemical	RQ
No ingredients listed in this section	

Product RQ: Not applicable (Notify EPA of product spills exceeding this amount.)

SARA TITLE III:

Section 302 Extremely Hazardous Substances:

Chemical Name	CAS #	RQ	TPQ
No ingredients listed in this section			

Section 311 and 312 Health and Physical Hazards:

Immediate	Delayed	Fire	Pressure	Reactivity
[no]	[no]	[no]	[no]	[no]

Section 313 Toxic Chemicals:

Chemical Name	CAS #	% by Weight
No ingredients listed in this section		

MATERIAL SAFETY DATA SHEET

Section 16. OTHER INFORMATION

HMIS RATINGS: Health = 0 Flammability = 0 Reactivity = 0
Personal Protective Equipment = A

Hazard rating scale: 0=Minimal 1=Slight 2=Moderate 3=Serious 4=Severe

MSDS REVISION SUMMARY:

This MSDS has been revised in Section 9.

PREPARED BY: P.J. Maloney/J.P. Myers

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 001
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

VAN WATERS & ROGERS INC. , SUBSIDIARY OF UNIVAR (206)889-3400
6100 CARILLON POINT , KIRKLAND , WA 98033

---------- EMERGENCY ASSISTANCE ----------

FOR EMERGENCY ASSISTANCE INVOLVING CHEMICALS CALL - CHEMTREC
(800)424-9300

---------- FOR PRODUCT AND SALES INFORMATION ----------

CONTACT YOUR LOCAL VAN WATERS & ROGERS BRANCH OFFICE AT
VW&R KENT 206-872-5000 KENT , WA

****
PRODUCT IDENTIFICATION
****

PRODUCT NAME: FERRIC CHLORIDE SOLUTION

MSDS #: P1096VS

DATE ISSUED: 11/01/91

ISSUED BY: 008856

****
MANUFACTURER'S MSDS
****

EMERGENCY TELEPHONE
(313) 571-1100

Ferric Chloride Solution

****
PRODUCT INFORMATION:
****

Product Name Ferric Chloride Solution

REPORT NUMBER: 971---
MSDS NO: P1096VS
EFFECTIVE DATE: 03/08/93

VAN WATERS & ROGERS INC.
MATERIAL SAFETY DATA SHEET

PAGE: 002
VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

Chemical Name and Synonyms	Iron Chloride Solution
Chemical Family and Formula	Inorganic Salt Solution, FeCl3
CAS Registry Number	7705-08-0
DOT Proper Shipping Name	Ferric Chloride Solution
DOT Hazard Class and ID Number	Corrosive Material, UN 2582
US Clean Water Act Reportable Quantity	RQ - 1000 lbs. (454 kg)

HAZARDOUS INGREDIENTS:

	% by Wt.	Exposure Limits	OSHA Classification
Ferric Chloride	37-45	Not established	Irritant
Hydrochloric Acid	< .9		Corrosive
Ferrous Chloride	< .5		Irritant

PERSONAL PROTECTION AND EXPOSURE CONTROL:

Ventilation
Provide good general room ventilation to minimize exposure to vapors or mist.

Respiratory
Use NIOSH/MSHA approved, full face respirator as appropriate. Consult respirator manufacturer to determine appropriate equipment.

Eye Protection
Wear splashproof chemical safety goggles. Eyewash fountains recommended in all storage and handling areas. Do not wear contact lenses.

Skin Protection
Wear impervious rubber gloves and protective clothing to minimize skin contact. Full-face shield and rubber footwear, acid-resistant hood and full-body suit recommended as appropriate. Safety shower recommended in all storage and handling areas.

HEALTH-HAZARD INFORMATION:

DANGER - CORROSIVE, MAY CAUSE SEVERE BURNS TO EYES AND SKIN IRRITATION.

FIRST AID MEASURES:

Eyes

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 003
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

Flush immediately with water for at least 15 minutes. Forcibly hold eyelids apart to ensure complete irrigation of eye/lid tissue. Get immediate medical attention.

Skin
Flush immediately with water for at least 15 minutes while removing contaminated clothing. Get immediate medical attention. Wash clothing before reuse.

Ingestion
Drink copious amounts of water. Do not induce vomiting. Get immediate medical attention.

Inhalation
Remove to fresh air. If not breathing, perform artificial respiration. Get medical attention.

Effects of Overexposure
Contact with liquid, mist, or vapor can cause immediate irritation or corrosive burns to all human tissue. Severity of the burn is generally determined by the concentration of the solution and duration of exposure. Contact with eyes may cause irritation and tearing and eye tissue discoloration, and may result in permanent visual loss unless removed quickly by thorough irrigation with water. Inhalation of concentrated vapor or mist may cause irritation of respiratory tract. Ingestion may cause liver and kidney damage, and may be fatal.

Toxicity
Oral LD50 (Rat): 900 mg/kg

****
PHYSICAL DATA:
****

Appearance and Odor	Reddish brown liquid, slight odor of iron/acid.
Solubility in Water	Complete
Vapor Pressure	Negligible
Specific Gravity (H2O= 1)	40% solution = 1.432 @ 17.5 Deg. C
Evaporation Rate (Butyl Acetate = 1)	>1
Boiling Point	110 Deg. C, 230 Deg. F
Melting Point, Deg. C	

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 004
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

(approx.) -50 Deg.

****
HANDLING AND STORAGE PRECAUTIONS:
****

Protect container from physical damage.
Do not strike containers or fittings with tools or hard objects.
Keep container closed and dry.
Store away from heat and oxidizing agents.
Wash thoroughly after handling.
Emptied container may retain vapor and product residue.

****
REACTIVITY DATA:
****

Conditions to Avoid
Material is stable when properly handled. Material is acidic and corrodes most metals. Avoid contact with strong alkalis and oxidizers.

Hazardous Decomposition Products
Decomposition/polymerization will not occur.

****
FIRE AND EXPLOSION HAZARDS:
****

Flash Point
Not flammable.

Fire Fighting and Personal Protection
Wear self-contained breathing apparatus and full protective clothing as appropriate for surrounding fire. Cool exterior of storage tanks.

Extinguishing Media
Use water spray, fog, foam, dry chemicals, CO2 or other agents as appropriate for surrounding fire.

Unusual Explosion Hazards
None.

****
SARA/TITLE III HAZARD CATEGORIES AND LISTS
****

Product Hazard Categories Lists

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 005
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

Chronic Health	YES	Extremely Hazardous Substance	NO
Acute Health	YES	CERCLA Hazardous Substance	YES
Fire Hazard	NO	Toxic Chemicals	YES
Pressure Hazard	NO		
Reactivity Hazard	YES		

NFCA - HMIS RATINGS
Health 3
Flammability 0
Reactivity 0
Personal protection to be supplied by user depending upon use conditions.

CANADIAN WHMIS CLASSIFICATION
D-1B; E

****
ENVIRONMENTAL PROTECTION:
****

Spill Control
Utilize full protective clothing including boots, and protective equipment as appropriate. Contain spill in order to prevent contamination of water way; neutralize with lime or soda ash. Flush with water in accordance with applicable regulations to waste treatment system. Spills of 1,000 lbs. or more must be reported to the National Response Center (800) 424-8802.

Waste Disposal
Dispose of spilled, neutralized, or waste product, contaminated soil and other contaminated materials in accordance with all local, state and federal regulations.

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 006
MSDS NO: P1096US MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

FOR ADDITIONAL INFORMATION

CONTACT: MSDS COORDINATOR VW&R KENT
DURING BUSINESS HOURS, PACIFIC TIME (206)889-3400

09/21/93 12:15 PRODUCT: CUST NO: ORDER NO:

NOTICE

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IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE,

WITH RESPECT TO THE PRODUCT OR INFORMATION PROVIDED HEREIN. **

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* * * E N D O F M S D S * * *

DON'T SAY IT --- *Write It!* DATE: 9-28-93

TO: John Locklair H4-67 FROM: E. M. Miller EMM R3-01

Telephone: 372-3832

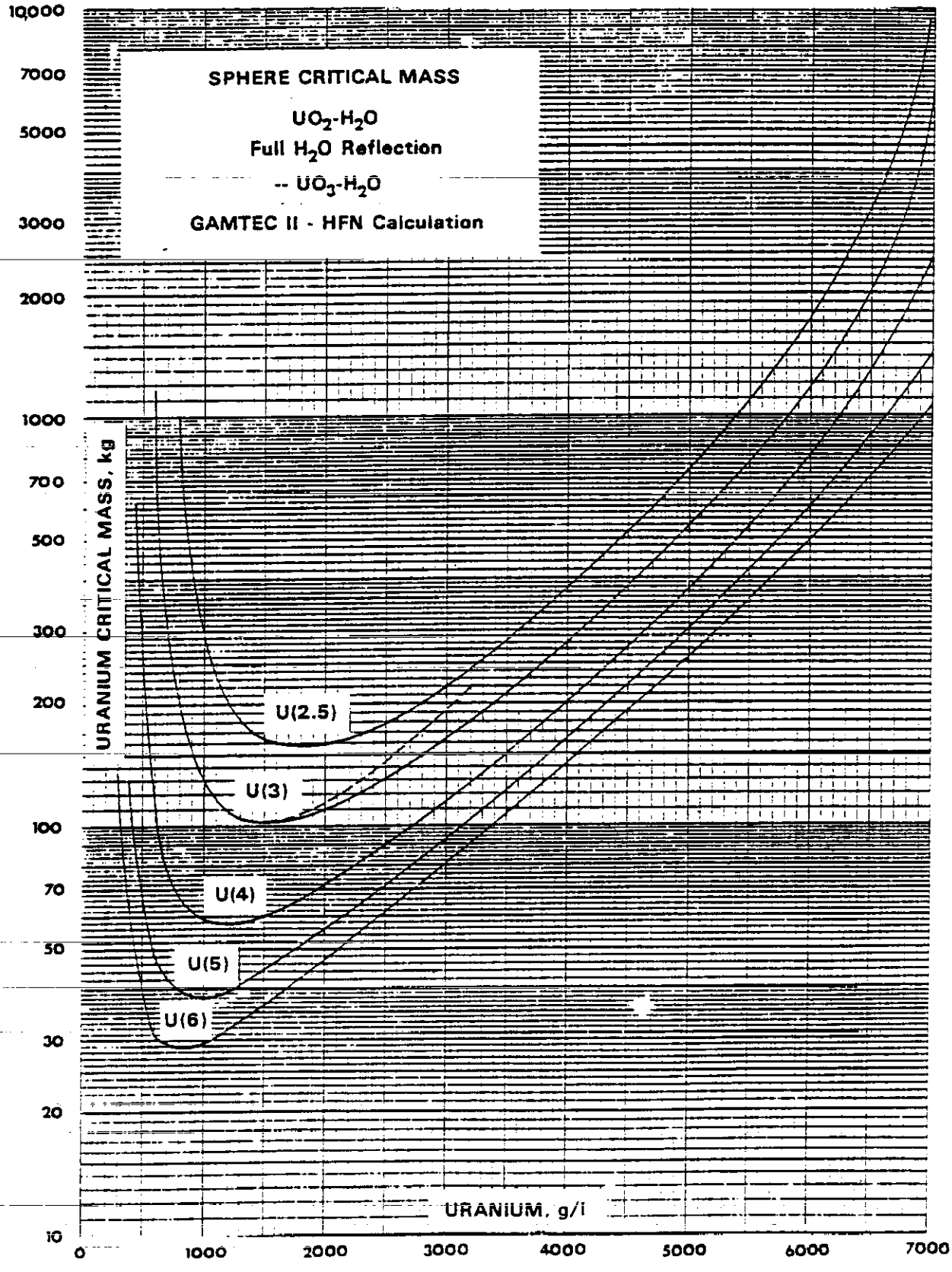
cc: D. E. Friar R3-01

SUBJECT: WATER TREATMENT/SOIL WASH CRITICALITY ASSESSMENT

A CC:Mail message of 9/21/93 from John A. Locklair requested a criticality assessment of the cleanup treatment that will remove solids from the water stored in tanks that came from the 300 Area process trench soils treatment. The solids in the water are to be settled out with a polymer and ferric chloride treatment. The solids in a slurry are then to be pumped into water tight metal B-25 boxes. Based on a January 13, 1992, evaluation by Hans Toffer, the uranium enrichment in the solids is estimated to be 0.988 wt%. Using seven water samples, the average uranium concentration is 0.04 g/L in the water and the largest sample concentration was 0.094 g/L. Using the 1.51E5 liters of waste water to be treated and that the solids are to be put into four B-25 boxes, a 1.44 Kg average uranium mass would be in each box. The total volume of solids in the water are calculated to be 7,550 liters. The concentration and total mass of uranium in each box can be conservatively taken as 1 g/L and 4 Kg in a box. The solids are characterized as a small amount of contaminants attached to Hanford soil.

Uranium enriched to less than 1 wt%, homogeneously mixed with water can not go critical per Note 3 to Table 1-4, Section 1 of WHC-CM-4-29 and data in ARC-600. The solids are to be pumped to the water tight metal boxes as a slurry. Thus the solids will have plenty of water. Even if the box contents dried out, the water of hydration and intersticial water would remain. In addition, the iron and chlorine used to settle out the solids would add to the neutron absorption of the water. For a uranium concentration of less than 100 g/L, ARC-600 Figure III.B.6-6 (attached) shows that for an enrichment less than 2.5 wt% over a 1000 Kg of uranium in water is required for criticality. This is much larger than the 4 Kg estimated to be in a box. ARC-600 Figure III.A.6(97)-4 (attached) gives the critical mass for 97 wt% plutonium-239 in saturated Hanford soil. For plutonium concentrations less than 6 g/L at least 5.5 Kg of plutonium is required for criticality. For the boxes, the concentration is less than 1 g/L, the enrichment is less than 1 wt%, not 97 wt%, and the total mass is at most 4 Kg. Although plutonium and uranium do not act exactly alike, the margin between the calculated quantities required for criticality and those in the boxes is so great that the boxes can be judged to have an adequate margin of safety even if dried out. In all cases, the mass of fissile material in a box is less than a critical mass by at least a factor of 100.

Therefore, the water treatment proposed poses no possible risk of a criticality accident.


SPHERE CRITICAL MASS
UO2-H2O
Full H2O Reflection
-- UO3-H2O
GAMTEC II - HFN Calculation
URANIUM CRITICAL MASS, kg
URANIUM, g/l
U(2.5)
U(3)
U(4)
U(5)
U(6)
10000
7000
5000
3000
2000
1000
700
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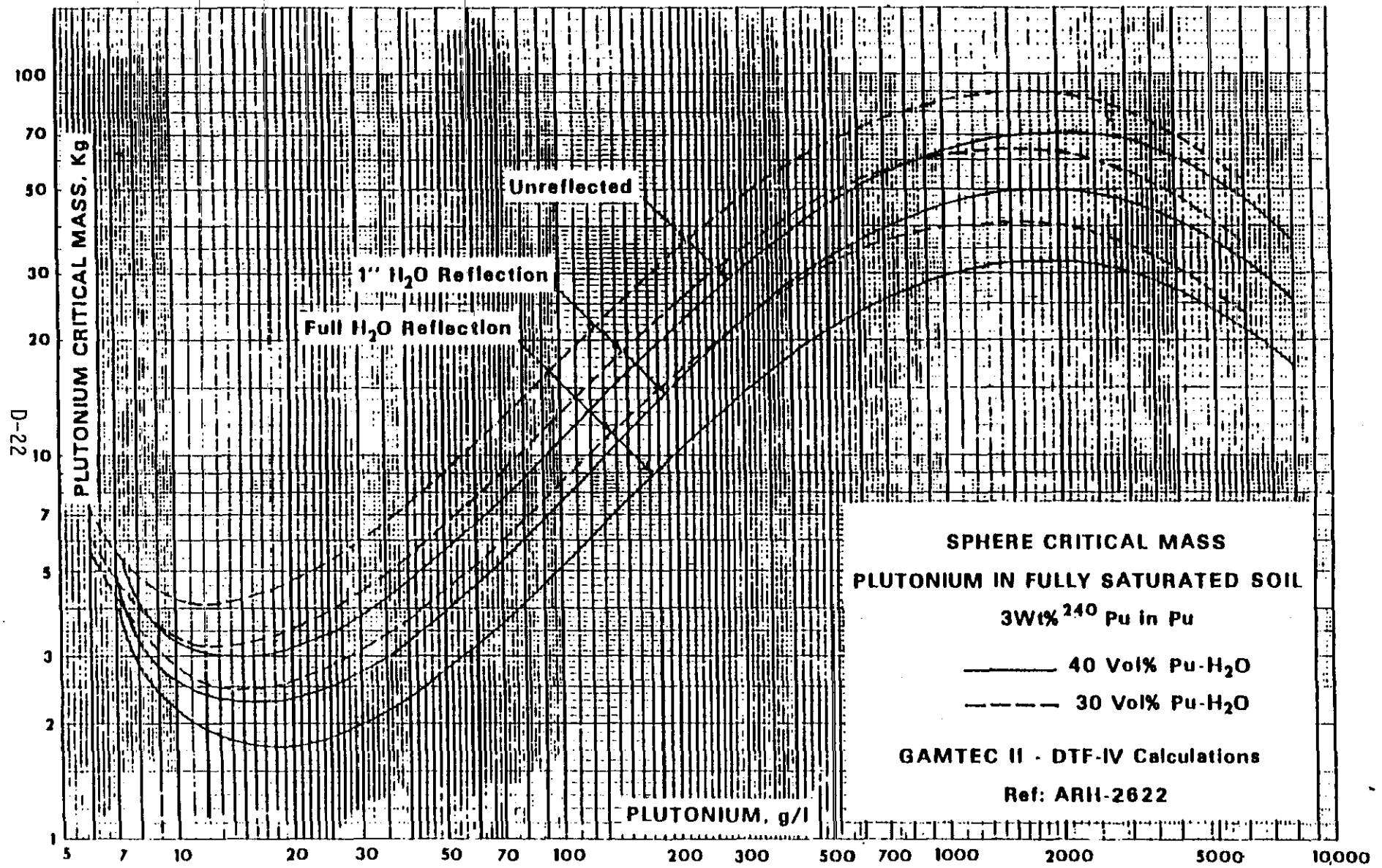

APPENDIX E

PURGEWATER COLLECTION CRITERIA

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Table E-1. Purgewater Collection Criteria*****.
(sheet 1 of 6)

Constiteunt	Detn. Limit	Collection Criteria	Units	Basis[1]
1,1,1,2-tetrachlorethane	10.0	50.0	PPB[2]	PQL
1,1,1-trichloromethane	5.0	2000.0	PPB	MCL
1,1,2,2-tetrachloroethane	5.0	24000.0	PPB	CFWTL
1,1,2-trichloromethane	5.0	2000.0	PPB	MCL[3]
1,1-dichloroethane	5.0	10.0	PPB	PQL
1,1-dichloroethylene	10.0	70.0	PPB	MCL
1,2,3,4-tetrachlorobenzene	10.0	500.0	PPB	CFWTL
1,2,3,5-tetrachlorobenzene	10.0	500.0	PPB	CFWTL
1,2,3-trichlorobenzene	10.0	500.0	PPB	CFWTL
1,2,3-trichloropropane	10.0	50.0	PPB	PQL
1,2,4,5-tetrachlorobenzene	10.0	100.0	PPB	PQL
1,2,4-trichlorobenzene	10.0	100.0	PPB	PQL
1,2-dibromo-3-chloropropane	10.0	50.0	PPB	PQL
1,2-dibromoethane	10.0	50.0	PPB	PQL
1,2-dichlorobenzene	10.0	500.0	PPB	CFWTL
1,2-dichloroethane	5.0	50.0	PPB	MCL
1,2-dichloropropane	5.0	57000.0	PPB	CFWTL
1,3,5-trichlorobenzene	10.0	500.0	PPB	CFWTL
1,3-dichlorobenzene	10.0	500.0	PPB	CFWTL
1,3-dichloropropane	5.0	2440.0	PPB	CFWTL
1,4-dichloro-2-butane	10.0	50.0	PPB	PQL
1,4-naphthoquinone	10.0	100.0	PPB	PQL
1-napthylamine	10.0	100.0	PPB	PQL
2,3,4,6-tetrachorophenol	10.0	100.0	PPB	PQL
2,4,5-T	2.0	20.0	PPB	PQL
2,4,5-TP silvex	2.0	100.0	PPB	MCL
2,4,5-trichlorophenol	10.0	100.0	PPB	PQL
2,4,5-trichlorophenol	10.0	9700.0	PPB	CFWTL
2,4-D	2.0	1000.0	PPB	MCL
2,4-dichlorophenol	10.0	3650.0	PPB	CFWTL
2,4-dimethylphenol	10.0	50.0	PPB	PQL
2,4-dinitrophenol	10.0	500.0	PPB	PQL
2,4-dinitrotoluene	10.0	2300.0	PPB	CFWTL
2,6-dichlorophenol	10.0	100.0	PPB	PQL
2,6-dinitrotoluene	10.0	2300.0	PPB	CFWTL
2-Hexanone	50.0	500.0	PPB	PQL
2-Methylnaphthalene	10.0	100.0	PPB	PQL
2-acatylaminofluorene	10.0	100.0	PPB	PQL
2-chloronaphthalene	10.0	100.0	PPB	PQL
2-chlorophenol	10.0	20000.0	PPB	CFWTL
2-naphthylamine	10.0	100.0	PPB	PQL
2-picoline	10.0	50.0	PPB	PQL
3,3'-dichlorobenzidine	10.0	200.0	PPB	PQL
3,3'-dimethylbenzidine	10.0	100.0	PPB	PQL

*****Derived from WHC-CM-7-5.

Table E-1. Purgewater Collection Criteria.
(sheet 2 of 6)

Constiteunt	Detn. Limit	Collection Criteria	Units	Basis[1]
3-methylcholanthrene	10.0	100.0	PPB	PQL
4,6-dinitro-o-cresol and salts	10.0	500.0	PPB	PQL
4-Nitroquinoline 1-oxide	10.0	100.0	PPB	PQL
4-aminobyphenyl	10.0	100.0	PPB	PQL
4-bromophenyl phenyl ether	10.0	100.0	PPB	PQL
5-nitro-o-toluidine	10.0	100.0	PPB	PQL
7,12-dimethylbenz[a]anthracane	10.0	100.0	PPB	PQL
Acenaphthalene	10.0	100.0	PPB	PQL
Acenapthene	10.0	5200.0	PPB	CFWTL
Acetone	10.0	1000.0	PPB	PQL
Acetonitrila	10.0	1000.0	PPB	PQL
Acetophenone	10.0	100.0	PPB	PQL
Acrolein	10.0	210.0	PPB	CFWTL
Acrylonitrile	10.0	25000.0	PPB	CFWTL
Aldrin	.1	.5	PPB	PQL
Allyl Chloride	100.0	100.0	PPB	PQL[4]
Alpha,alpha-dimethylphenethyla	10.0	100.0	PPB	PQL
Alpha-BHC	.1	.5	PPB	PQL
Aniline	10.0	100.0	PPB	PQL
Anthracane	10.0	100.0	PPB	PQL
Antimony, filtered	100.0	16000.0	PPB	CFWTL
Antimony-125	48.0	3000.0	pCi/L	MCL
Aramite	10.0	100.0	PPB	CFWTL
Arochlor 1016	1.0	1.0	PPB	CFWTL[4]
Arochlor 1221	1.0	1.0	PPB	CFWTL[4]
Arochlor 1232	1.0	1.0	PPB	CFWTL[4]
Arochlor 1242	1.0	1.0	PPB	CFWTL[4]
Arochlor 1248	1.0	1.0	PPB	CFWTL[4]
Arochlor 1254	1.0	1.0	PPB	CFWTL[4]
Arochlor 1260	1.0	1.0	PPB	CFWTL[4]
Arsenic, filtered	5.0	480.0	PPB	CFWTL
Barium, filtered	6.0	10000.0	PPB	MCL
Benz[a]anthracane	10.0	100.0	PPB	PQL
Benzene	5.0	50.0	PPB	MCL
Benzo(ghi)perylene	10.0	100.0	PPB	PQL
Benzo(k)fluoranthene	10.0	100.0	PPB	PQL
Benzo(a)pyrene	10.0	190.0	PPB	PQL
Benzo(b)fluoranthene	10.0	100.0	PPB	PQL
Benzyl Alcohol	10.0	200.0	PPB	PQL
Beryllium, filtered	5.0	53.0	PPB	CFWTL
Beta-BHC	.1	.5	PPB	PQL
Bis(1-chloro-1-methyl) ether	10.0	100.0	PPB	PQL
Bis(2-chloroethoxy) methane	10.0	100.0	PPB	PQL
Bis(2-chloroethyl) ether	10.0	100.0	PPB	PQL

Table E-1. Purgewater Collection Criteria.
(sheet 3 of 6)

Constituent	Detn. Limit	Collection Criteria	Units	Basis[1]
Bis(chloromethly) ether	5.0	100.0	PPB	PQL
Bromodichloromethane	5.0	10.0	PPB	PQL
Bromoform	5.0	20.0	PPB	PQL
Cadmium, filtered	2.0	11.0	PPB	
CFWTLCarbon disulfide	10.0	50.0	PPB	PQL
Carbon tetrachloride	5.0	50.0	PPB	MCL
Carbon-14	20.0	20000.0	pCi/L	MCL
Cesium-137	20.0	2000.0	pCi/L	MCL
Chlordane	1.0	1.0	PPB	CFWTL[4]
Chloride	500.0	2500000.0	PPB	MCL
Chlorobenzene	5.0	20.0	PPB	PQL
Chlorobenzene (by ABN)	10.0	20.0	PPB	PQL
Chlorobenzilate	300.0	300.0	PPB	PQL
Chloroethane	10.0	50.0	PPB	PQL
Chloroform	5.0	1000.0	PPB	MCL
Chromium(VI)	50.0	110.0	PPB	CFWTL
Chromium, filtered	10.0	110.0	PPB	CFWTL[5]
Chrysene	10.0	100.0	PPB	PQL
Cobalt-60	22.5	1000.0	pCi/L	MCL
Copper, filtered	10.0	120.0	PPB	CFWTL
Cresols	10.0	100.0	PPB	PQL
Cyanide	10.0	52.0	PPB	CFWTL
DOD	.1	1.0	PPB	PQL
DOE	.1	0.5	PPB	PQL
DOT	.1	.1	PPB	CFWTL[4]
Delta-BHC	.1	1.0	PPB	PQL
Di-n-propylnitrosamine	10.0	100.0	PPB	PQL
Dibenz[a,h]anthracene	10.0	100.0	PPB	PQL
Dibenzofuran	10.0	100.0	PPB	PQL
Dibromochloromethane	5.0	10.0	PPB	PQL
Dichlorodifluoromethane	10.0	50.0	PPB	PQL
Dieldrin	.1	.1	PPB	CFWTL[4]
Dillate	10.0	100.0	PPB	PQL
Dimethoate	2.0	100.0	PPB	PQL
Dinitrobenzene	10.0	100.0	PPB	PQL
Dinoseb	10.0	10.0	PPB	PQL
Dioxane	500.0	1500.0	PPB	PQL
Dioxin	.1	.1	PPB	CFWTL[4]
Diphenylamine	10.0	100.0	PPB	PQL
Disulfoton	2.0	20.0	PPB	PQL
Endosulfan I	.1	.6	PPB	CFWTL
Endrin	.1	.1	PPB	CFWTL[4]
Ethyl benzene	5.0	20.0	PPB	PQL
Ethyl methacrylate	10.0	50.0	PPB	PQL

Table E-1. Purgewater Collection Criteria.
(sheet 4 of 6)

Constituent	Detn. Limit	Collection Criteria	Units	Basis[1]
Ethyl methanesulfonate	10.0	100.0	PPB	PQL
Fluoranthene	10.0	100.0	PPB	PQL
Fluorene	10.0	100.0	PPB	MCL
Fluoride	500.0	20000.0	PPB	MCL
Gross alpha	4.0	150.0	pCi/L	MCL
Gross beta	8.0	500.0	pCi/L	
MCLHeptachlor	.1	.1	PPB	CFWTL[4]
Heptchlor epoxide	.1	10.0	PPB	PQL
Hexachlorobenzene	10.0	10.0	PPB	PQL[4]
Hexachlorobutadiene	10.0	93.0	PPB	CFWTL
Hexachlorocyclopentadiene	10.0	52.0	PPB	CFWTL
Hexachloroethane	10.0	5400.0	PPB	CFWTL
Hexachlorophene	10.0	100.0	PPB	PQL
Hexachloropropene	10.0	100.0	PPB	PQL
Hydrogen sulfide	10.0	20.0	PPB	CFWTL
Indeno(1,2,,3-cd)pyrene	10.0	100.0	PPB	PQL
Iodine-129	1.0	10.0	pCi/L	MCL
Iodine-131	20.0	30.0	pCi/L	MCL
Iodomethane	10.0	50.0	PPB	PQL
Iron, filtered	30.0	3000.0	PPB	MCL
Isobutyl Alcohol	10000.0	10000.0	PPB	PQL[4]
Isodrin	10.0	100.0	PPB	PQL
Isophorone	10.0	100.0	PPB	PQL
Isosafrole	10.0	100.0	PPB	PQL
Kapone	1.0	100.0	PPB	PQL
Lead, filtered	5.0	32.0	PPB	CFWTL
Lindane, gamma-BHC	.1	.8	PPB	CFWTL
Manganese, filtered	5.0	500.0	PPB	MCL
Mercury, filtered	.1	.1	PPB	CFWTL
Methacrylonitrile	10.0	50.0	PPB	PQL
Methapyrilene	10.0	100.0	PPB	PQL
Methoxychlor	3.0	3.0	PPB	CFWTL[4]
Methyl bromide	10.0	100.0	PPB	PQL
Methyl chloride	10.0	10.0	PPB	PQL
Methyl ethyl ketone	10.0	100.0	PPB	PQL
Methyl isobutyl ketone	10.0	50.0	PPB	PQL
Methyl methacrylate	10.0	20.0	PPB	PQL
Methyl methanesulfonate	10.0	100.0	PPB	PQL
Methyl parathion	2.0	5.0	PPB	PQL
N-Nitrosodiphenylamine	10.0	100.0	PPB	PQL
N-nitrosodi-n-butylamine	10.0	100.0	PPB	PQL
N-nitrosodiethylamine	10.0	100.0	PPB	PQL
N-nitrosodimethylamine	10.0	100.0	PPB	PQL
N-nitrosomethylethylamine	10.0	100.0	PPB	PQL

Table E-1. Purgewater Collection Criteria.
(sheet 5 of 6)

Constituent	Detn. Limit	Collection Criteria	Units	Basis[1]
N-nitrosomorpholine	10.0	100.0	PPB	PQL
N-nitrosopiperidine	10.0	100.0	PPB	PQL
Naphthalene	10.0	6200.0	PPB	CFWTL
Nickel, filtered	10.0	1600.0	PPB	CFWTL
Nickel-63	10.0	500.0	pCi/L	MCL
Nitrate	500.0	450000.0	PPB	MCL
Nitrobenzine	10.0	100.0	PPB	PQL
Nitrosopyrrolidine	10.0	100.0	PPB	PQL
0,0,0-triethyl phosphorothioate	10.0	100.0	PPB	PQL
O-toluidine hydrochloride	10.0	100.0	PPB	PQL
P-chloro-m-cresol	10.0	50.0	PPB	PQL
P-chloroaniline	10.0	200.0	PPB	PQL
P-dimethylaminoazobenzene	10.0	100.0	PPB	PQL
P-nitroaniline	10.0	500.0	PPB	PQL
Parathion	2.0	2.0	PPB	CFWTL[4]
Pcdd's	.0	.1	PPB	PQL
Pcdf's	.0	.1	PPB	PQL
Pentachlorobenzene	10.0	100.0	PPB	PQL
Pentachloroethane	10.0	11000.0	PPB	CFWTL
Pentachloronitrobenzene	10.0	100.0	PPB	PQL
Pentachlorophenol	50.0	130.0	PPB	CFWTL
Phenacatin	10.0	100.0	PPB	PQL
Phenanthrene	10.0	100.0	PPB	PQL
Phenol	10.0	25600.0	PPB	CFWTL
Phenylenediamine	10.0	100.0	PPB	PQL
Phorate	2.0	20.0	PPB	PQL
Phthalic acid esters	10.0	30.0	PPB	CFWTL
Plutonium-238	.1	16.0	pCi/L	DCG
Plutonium-239,40	.1	12.0	pCi/L	DCG
Pronamide	10.0	100.0	PPB	PQL
Propionitrile	5.0	50.0	PPB	PQL
Pyrene	10.0	100.0	PPB	PQL
Pyridine	500.0	500.0	PPB	PQL
Radium	1.0	50.0	pCi/L	MCL
Ruthenium-103	20.0	2000.0	PPB	MCL
Ruthenium-106	172.5	300.0	pCi/L	MCL
Safrol	10.0	100.0	PPB	PQL
Selenium	5.0	100.0	PPB	MCL
Silver, filtered	10.0	10.0	PPB	CFWTL[4]
Strontium-89	5.0	200.0	pCi/L	MCL
Strontium-90	5.0	80.0	pCi/L	MCL
Styrene	5.0	10.0	PPB	PQL
Sulfate	500.0	2500000.0	PPB	MCL
Sym-trinitrobenzene	10.0	100.0	PPB	PQL

Table E-1. Purgewater Collection Criteria.
(sheet 6 of 6)

Constituent	Detn. Limit	Collection Criteria	Units	Basis[1]
Technetium-99	15.0	9000.0	pCi/L	MCL
Tetrachloroethylene	5.0	8400.0	PPB	CFWTL
Tetraethylpyrophosphate	2.0	100.0	PPB	PQL
Thallium	5.0	400.0	PPB	CFWTL
Tin, filtered	30.0	80000.0	PPB	PQL
Toluene	5.0	20.0	PPB	PQL
Toxaphene	1.0	1.0	PPB	CFWTL[4]
Trans-1,2-dichloroethylene	5.0	10.0	PPB	PQL
Trichloroethylene	5.0	50.0	PPB	MCL
Trichloromonofluoromethane	10.0	50.0	PPB	
PQLUranium	.5	400.0	pCi/L	DCG
Uranium, chemical	.7	590.0	UG/L	DCG
Vanadium, filtered	5.0	400.0	PPB	PQL
Vinyl Acetate	5.0	50.0	PPB	PQL
Vinyl chloride	10.0	20.0	PPB	MCL
Xylene-m	5.0	50.0	PPB	PQL
Xylene-a,o	5.0	50.0	PPB	PQL
Zinc, filtered	5.0	1100.0	PPB	CFWTL
m-Nitroaniline	10.0	500.0	PPB	PQL
o-Nitroaniline	10.0	500.0	PPB	PQL
p-Dichlorobenzene	10.0	500.0	PPB	PQL
p-Nitrophenol	10.0	1500.0	PPB	CFWTL

[1]The bases for collection of criteria are as follows:

MCL	-	10% the Maximum Contaminant Level as defined in 40 CFR 141, 40 CFR 143, and EPA 570/9-76-003
PQL	-	10% the Practical Quantitation Limit as listed in Appendix IX of 40 CFR 264
CFWTL	-	10% the Chronic Freshwater Toxicity Level as defined in EPA 440/5-86-001
DCG	-	10% one-twenty-fifth of the Derived Concentration Guide as listed in DOE Order 5400.5

[2]Parts per billion.

[3]Based on 10% MCL for 1,1,1-trichloromethane.

[4]Criteria are below current detection limit so detection limit is used as criterion.

[5]All chromium is assumed to be hexavalent.

REFERENCES

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EPA, 1986, *Quality Criteria for Water*, EPA 440/5-86/001, U. S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington D. C.

40 CFR 141, 1993, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 143, 1993, "National Secondary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 264, 1993, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

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